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VOL. 20 DECEMBER, 1927 No. 6

SOME EFFECTS OF ALTERNATING TEMPERATURES ON THE GROWTH AND METABOLISM OF CUTWORM LARVAE[1]

By WILLIAM C. COOK, *Assistant Entomologist, Montana Experiment Station*

ABSTRACT

The first part of this paper presents the results of experiments in which larvae of *Porosagrotis orthogonia* Morr. were reared with daily alternations of high and low temperature. It was found that growth was accelerated by these alternations, the highest acceleration being for an eight hour exposure to high temperatures.

In the second part of the paper, experiments are discussed in which the metabolism of larvae of *Chorizagrotis auxiliaris* Grt. was measured after varying exposures to high temperatures. Here also it was found that metabolism, as measured by carbon dioxide output, also showed a maximum for an eight hour exposure.

Both sets of experiments are discussed in relation to current chemical theories, and a time-temperature-rate surface is developed which shows the general relationship.

INTRODUCTION

There are many generalizations scattered through the literature regarding the stimulating effects of varying temperatures, but there are very few experimental data available. All workers with temperature recognize that a constant temperature has a different effect upon growth and metabolism than a varying temperature with the same mean value. Some recent experiments of J. R. Parker (unpublished) upon *Melanoplus atlanis*, in which he exposed hoppers to two different constant temperatures each day, were very suggestive, and the search for an explanation led me into the investigations which are presented here.

Many years ago, Blackman (1905), working upon the carbon assimilation of green leaves, developed a theory to explain the effects of short exposures to high temperature upon plant metabolism. He exposed cherry laurel leaves to high temperatures and measured their carbon assimilation after various periods of time, and he reached the following conclusions:

[1]Contribution from the Entomology Department, Montana Agricultural Experiment Station.

"1. At high temperatures (30°C and above for the leaves of cherry laurel) the initial rate of assimilation cannot be maintained, but falls off regularly.

"2. The higher the temperature the more rapid is the rate of falling off.

"3. The falling off at any given temperature is fastest at first and subsequently becomes less rapid."

Below 25° he found no falling off in carbon assimilation with time. He assumed that the rates for any period at these lower temperatures would fall on an exponential curve, following van't Hoff's law. He calculated a curve to fit these, and extended it up to the thermal death point of the plant. He then assumed that this curve represented the theoretical initial high value for each temperature, which fell off so rapidly as to be incapable of measurement, reaching in a short time the lower values actually found. As a corollary of his main proposition, he assumed a temperature at which the drop would be so rapid as to reach zero within any specified short time, and hence could not be measured. This point, the upper thermal death point of the organism, he called the "extinction point."

Kanitz (1915, p. 20) discusses this work of Blackman in detail, and disagrees with his conclusions, but this conception of the interrelation of time and temperature has proven so helpful in chemical work that Bayliss (1913) uses it as a "complete explanation" of the effects of these factors upon enzyme reactions.

Experimental Work

Two sets of experiments were performed during the winter of 1925–26 with the object of testing the value of Blackman's theory in interpreting the facts of insect growth and metabolism. The first experiments were planned to find the effects of alternating temperatures upon growth, and larvae of *Porosagrotis orthogonia* Morr. were used. The second experiments were planned to check the actual metabolism of the insect during exposures to high temperatures, using the carbon dioxide output as an index of metabolic rate. The method used required a large number of larvae, and the supply of *Porosagrotis orthogonia* was limited, so larvae of *Chorizagrotis auxiliaris* Grt. were brought in from the field. The use of two species obviously precludes a direct check between the two sets of experiments, but it has the advantage of allowing comparison between species, to bring out common features in the results.

I. The Effects of Alternating Temperatures Upon the Growth of Larvae of *Porosagrotis orthogonia* Morr.

The stock used in these experiments came from eggs laid by females captured in the fall of 1925. These eggs were developed nearly to the

hatching point and then held at 0°C until needed. A few hours exposure to room temperature in the presence of moisture caused them to hatch.

The newly hatched larvae were divided into lots of eleven each. Seven such lots were placed at constant temperatures of 12°, 16°, 22° 27°, 32°, and 37°C., to serve as checks. Other lots were then taken for exposure to alternating temperatures. For high temperatures 22°, 27°, 32°, and 37° were used, while 8° served as the low temperature for all lots. Four lots were placed at each high temperature, one each for two, four, eight and sixteen hours per day. The remainder of the day was spent at 8° in each case. Additional lots were placed at the two higher temperatures for one hour per day and spent twenty-three hours at 8°. The larvae were all examined daily at the close of the exposure to high temperature, and all molts noted. Under these conditions, especially in those lots exposed to high temperatures for four hours or less per day, the larvae developed rather slowly. In order to limit the duration of the experiment the length of the first instar was taken as the growth period.

Table 1 presents the experimental results, giving the total hours, both at high and at low temperature, required for each lot to complete the first instar. These figures are mean values for the surviving larvae of each lot. At least nine larvae lived through the experiment in every case except at 37°, where five larvae survived a daily exposure of eight hours, and eight one of four hours daily.

TABLE 1. DURATION OF FIRST INSTAR OF *Porosagrotis orthogonia* AT CONSTANT AND AT ALTERNATING TEMPERATURES

Hours per day at High Temperature	24	16		8		4		2		1	
High Temperature Degrees C.	Check	Total Hours at High	Low	Total Hours at High	Low	Total Hours at High	Low	Total Hours at High	Low	Total Hours at High	Low
12	462.0										
16	212.6										
19	138.0										
22	118.8	97.6	40.8	75.2	134.4	67.2	316.0	54.6	578.6		
27	78.0	74.5	29.3	58.4	100.8	51.0	235.0	42.6	446.6		
32	66.0	56.8	20.4	52.4	88.8	45.4	200.0	35.6	369.6	27.8	616.4
37	Died	Died	Died	80.0	144.0	60.0	280.0	46.0	484.0	31.0	690.0

Growth rate, for the purpose of these experiments, is defined as the reciprocal of the time required to complete the first instar, or, the value of one hour at a given temperature. A larva which molted after one

hundred hours at 22°, for example, would have a growth rate of 0.01. In the alternating temperatures the calculation of growth rate is complicated by the necessity of allowing for the slight amount of growth per hour which occurred during the time spent in the cold. Growth at a

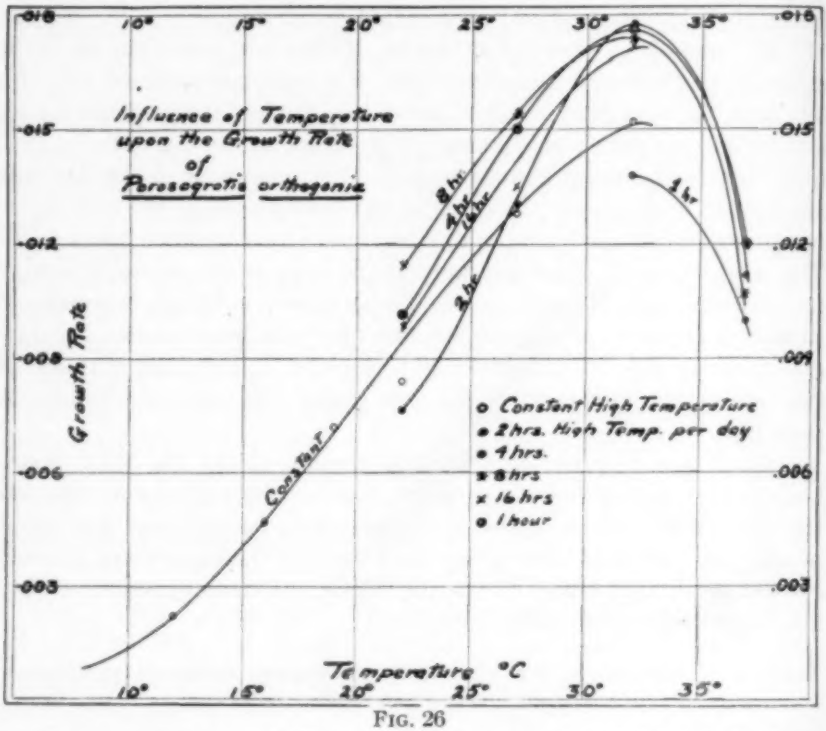

FIG. 26

constant temperature of 8°C is very slow. Larvae of this species have been found to live at 8° for considerable periods, but very little feeding occurs. The time spent at 8° is very large in some cases, however, and a considerable total growth must have occurred. An inspection of the curve labeled "Constant" in Figure 26 shows that the value 0.001 is not far from the probable growth rate at 8°. Assuming this value, a sample calculation follows:

The larvae exposed to 22° for 16 hours daily molted after 97.6 hours at 22° and 40.8 hours at 8°. (Table 1).

Total development = 1.0000
40.8 hours at 8° (value 0.001) = 0.0408

By subtraction this leaves 0.9592 for the value of 97.6 hours at 22°.

Hence, the value of 1 hour at 22° = 0.0099 which is taken as the growth rate for this lot.

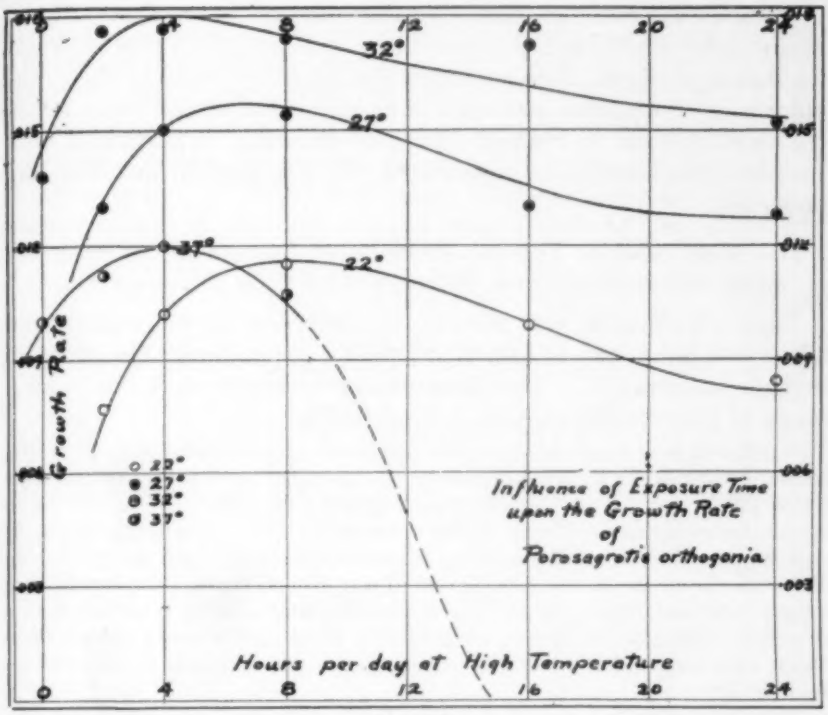

FIG. 27

The growth rates were so calculated for each lot in the series, and are presented in Table 2 together with the growth rates of the larvae held at constant temperatures.

TABLE 2. GROWTH RATE FOR FIRST INSTAR OF *Porosagrotis orthogonia* AT CONSTANT AND AT ALTERNATING TEMPERATURES

These values are calculated from the times in Table 1, assuming .001 as the value of one hour at eight degrees Centigrade.

Hours per Day at High Temperature	24	16	8	4	2	1
High Temperature Degrees C.	Figures below give the value of one hour at high temperature					
12	.0022					
16	.0047					
19	.0072					
22	.0084	.0099	.0115	.0102	.0077	
27	.0128	.0130	.0154	.0150	.0130	
32	.0152	.0172	.0174	.0176	.0177	.0138
37	——	——	.0107	.0120	.0112	.0100

These growth rates are plotted against temperature in Figure 26, and against hours per day at high temperature in Figure 27. Quite evidently the curves of Figure 27 do not follow Blackman's theory, for the initial value is not the highest, and there is an interval of several hours before the maximum rate is reached. Further discussion is postponed until the data from metabolism experiments with *Chorizagrotis auxiliaris* are presented.

II. The Carbon Dioxide Output of Larvae of *Chorizagrotis auxiliaris* Grote During Exposures to High Temperatures

These experiments were planned to check the growth experiments of the first series, and to find what actually occurs during the exposure to high temperature. The determinations were made by a modification of the titration method of Lund (1919).

Single larvae were suspended in tightly corked bottles containing 10 cc. of N/100 barium hydroxide for a period of twenty minutes (22°C and above) or one hour (below 22°C). At the end of this period the larvae were removed and the excess barium hydroxide titrated with N/200 hydrochloric acid. Two blank bottles in each set gave the correction for carbon dioxide in the confined air, and that given off by the larvae in the other bottles was found by difference. The larvae were weighed after each experiment, and the results calculated in terms of carbon dioxide given off by one gram of larva in one hour. To avoid cumbersome decimals, these results have been multiplied by 1000, giving grams carbon dioxide per kilogram of larva per hour.

Experiments were run in sets of ten, each set containing eight larvae and two blanks. The larvae used weighed from 0.3 to 0.9 gram each. The results recorded here are the average of at least sixteen larvae for each determination. In most cases thirty-two were used.

The experimental procedure follows: Well fed larvae were placed at 0°C for from sixteen to forty hours, but rarely longer. They were then placed in warm bottles at the desired temperature and their carbon dioxide output determined at once. After weighing, they were allowed to feed at the high temperature for the remainder of the experiment, the feeding being interrupted at intervals for further carbon dioxide determinations. The exact time schedule of a typical experiment follows.

8:00 a. m.	Larvae taken from refrigerator	
8:00– 8:20	CO_2 determination at 32°C.	(designated 0 value)
8:20– 9:00	Allowed to feed at 32°	
9:00– 9:20	CO_2 determination	(designated 1 hour value)
9:20–10:00	Allowed to feed	
10:00–10:20	CO_2 determination	(designated 2 hour value)
10:20–12:00	Allowed to feed	
12:00–12:20 p. m.	CO_2 determination	(designated 4 hour value)
12:20– 4:00	Allowed to feed	
4:00– 4:20	CO_2 determination	(designated 8 hour value)
4:20– 8:00 a. m.	Allowed to feed	
8:00– 8:20	CO_2 determination	(designated 24 hour value)

For determination of metabolic rate after a sixteen hour exposure, a separate set of larvae was necessary. They were usually taken from the refrigerator at 5 p. m., a "0" determination made, and then they were allowed to feed at the high temperature until 9 a. m. the next morning, when the sixteen hour determination was made.

These determinations give the actual value of the metabolism at the time of measurement, and show what actually takes place during the exposure period. They are tabulated in Table 3. They have also been plotted against time at high temperature in Figure 28. The curves at 8°

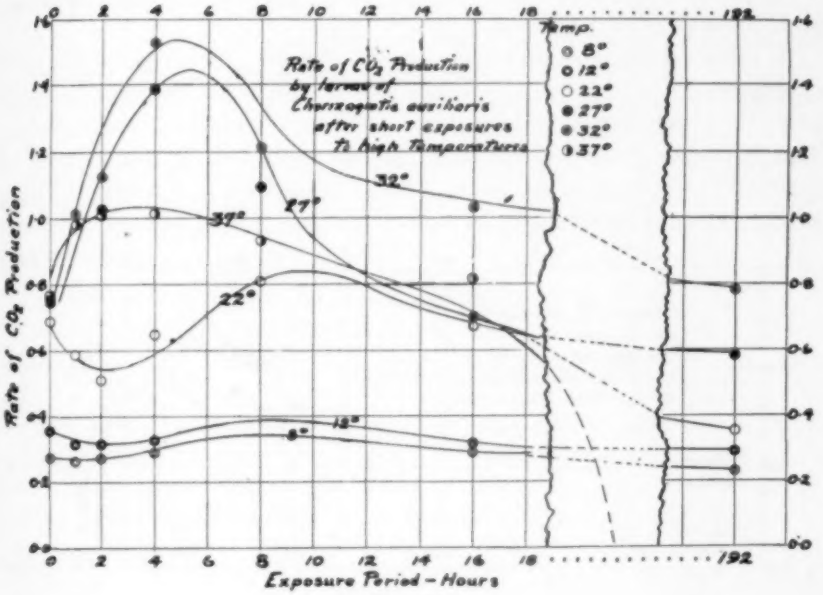

FIG. 28

and 12° are approximately straight lines. At 22° there is an initial drop, of unknown significance, followed by a rise to a maximum after eight hours, and then by a steady decline to the final value. At 27° and 32° the maximum comes after about four hours, and at 37° it falls between two and four hours. The 37° curve falls to zero in about 150 hours, as this exposure usually kills the larvae.

At the intermediate temperatures it is seen that the metabolism rises in a few hours to a high value, about twice that attained under constant conditions. If the growth is checked by cooling to near the point of dormancy, and the larva is again exposed to the high temperature, this is repeated, and an accelerated growth rate maintained.

TABLE 3. RATE OF CARBON DIOXIDE PRODUCTION OF LARVAE OF *Chorizagrotis auxiliaris* AT THE END OF VARIOUS SHORT EXPOSURES TO HIGH TEMPERATURES

Temperature	Exposure Period in Hours						
Degrees C.	0	1	2	4	8	16	192
8	0.277	0.269	0.276	0.285		0.294	0.216
12	0.359	0.313	0.315	0.325		0.315	0.292
22	0.688	0.588	0.507	0.642	0.808	0.676	0.359
27	0.755		1.026	1.388	1.097	0.696	0.585
32	0.748	1.017	1.121	1.530	1.209	1.032	0.782
37	0.762	0.988	1.010	1.019	0.935	0.814	Died

The figures in this table are in terms of grams carbon dioxide given off in one hour by one kilogram of material.

In order to compare these curves with the growth curves of the first experiment, it is necessary to recalculate the results in terms of average CO_2 production during periods of one, two, four, eight and sixteen hours. This is done by reading the intermediate ordinates on the curves of Figure 28 and obtaining an average value for the desired period. These average rates of metabolism have been computed, and they are given in

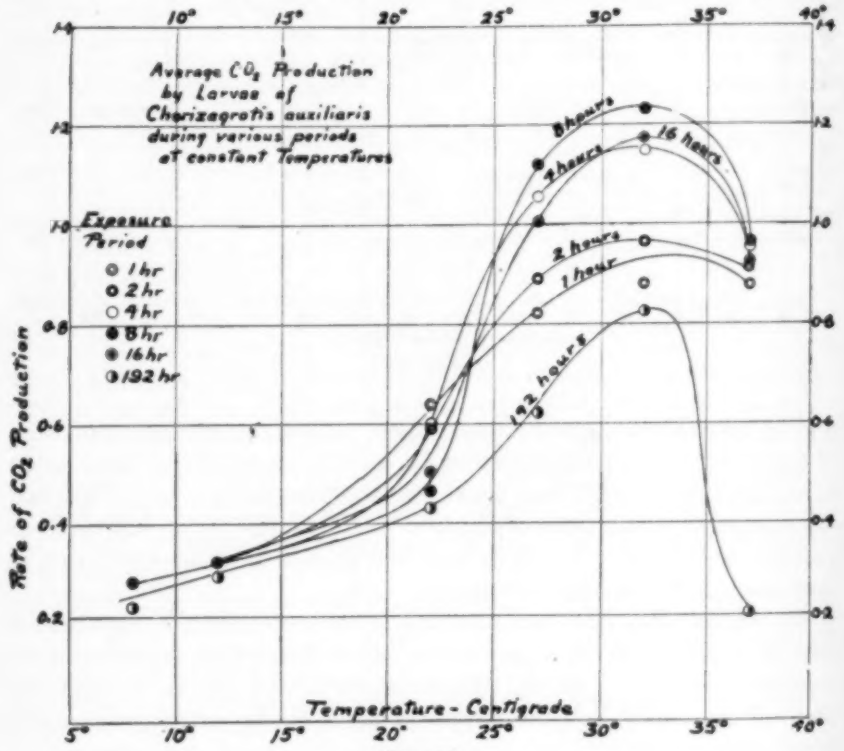

FIG. 29

Table 4. They are shown plotted against temperature in Figure 29, and against length of exposure period in Figure 30.

TABLE 4. AVERAGE RATE OF CARBON DIOXIDE PRODUCTION BY LARVAE OF *Chorizagrotis auxiliaris* DURING SHORT EXPOSURES TO HIGH TEMPERATURES

Temperature	Exposure Period in Hours								
Degrees C.	1	2	4	8	16	24	48	96	192
8	0.273	0.275	0.280	0.284	0.288	0.282	0.262	0.242	0.229
12	0.336	0.325	0.323	0.325	0.323	0.319	0.312	0.304	0.298
22	0.638	0.594	0.600	0.665	0.701	0.680	0.615	0.523	0.441
27	0.822	0.890	1.053	1.121	1.004	0.890	0.747	0.669	0.631
32	0.883	0.962	1.148	1.229	1.173	1.104	0.982	0.891	0.837
37	0.875	0.920	0.959	0.962	0.921	0.850	0.637	0.406	0.000*

*Larvae die in about 150 hours at 37 degrees C.

The figures in this table are in terms of grams carbon dioxide given off in one hour by one kilogram of material.

A direct comparison of these curves with Figures 26 and 27 shows that the same forces are at work in both cases. Both curves show a gradual rise to a maximum in four to eight hours, followed by a more gradual drop. The experimental error is high in both cases, but is higher in the growth curves than in the metabolism curves, as the number of larvae is smaller in the growth experiments.

DISCUSSION

In order to reach a sound theoretical basis for the interpretation of these curves, it is necessary to view the problem from the standpoint of enzyme chemistry. The first point of similarity between the insect growth and metabolism curves and curves for the rate of reaction of enzymes is found in the general shape of the limiting curve, labeled "*Constant*" in Figure 1, and "*192 hours*" in Figure 29. This curve rises rather slowly at first, then rapidly approaches a maximum, where it slows to a standstill and then rapidly drops to zero. Figure 31 shows a similar curve for the effect of temperature upon the activity of wheat diastase, from data of Rumsey (1922).

In accordance with the general theory of Blackman (loc. cit.) this curve may be explained as a balance between an increasing rate of activity on the part of the enzyme and a similarly increasing rate of destruction of the enzyme at high temperature, which finally results in total destruction of the enzyme within a short period. At temperatures below the upper thermal death point the activity does not reach zero, but declines to a low constant value. This value is generally interpreted as representing an equilibrium between production of new enzyme and inactivation, in the case of the enzyme reaction, and might possibly

be interpreted as a similar equilibrium between rate of production of new tissue and the elimination of waste products, in the case of the insect.

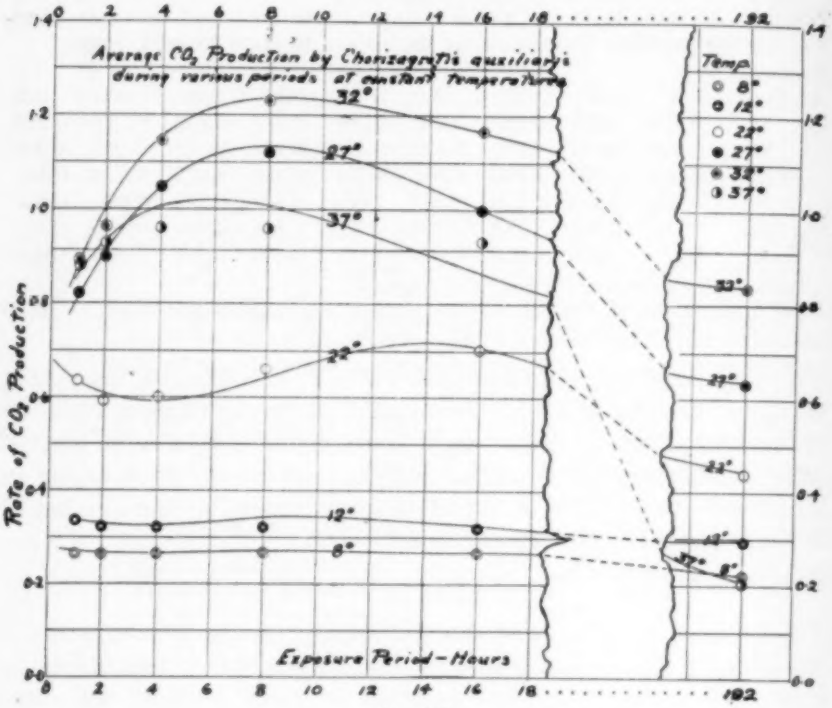

FIG. 30

Crozier (1924 and elsewhere) has shown that the chemical equation of Arrhenius:

$$K^1 = K_0 \; e^{\frac{a}{2}\left[\frac{T_1 - T_0}{T_1 T_0}\right]} \qquad \ldots\ldots\ldots\ldots (1)$$

holds for the effects of temperature upon many physiological reactions. In this equation, K_0 and K_1 are the rates of reaction at the two absolute Centigrade temperatures T_0 and T_1, e is the base of the natural system of logarithms, and a is a constant determined from the data, which Crozier designates the "critical thermal increment." Arrhenius interprets a as the heat necessary to activate 1 mol of inactive substance. It is theoretically a constant for any given reaction, and may be used to calculate the rate of reaction K_x for any temperature, when K_0 has been found.

Assuming that the growth curves are the resultants of opposing reactions, it should be possible to fit two such curves as (1) to the data, and reproduce the experimental curve. The resultant curve would be of the form

$$K_1 = K_0 [e^{\alpha} + e^{\beta}] \quad \ldots\ldots\ldots\ldots \quad (2)$$

in which α and β represent two exponents of the form of that in equation (1), with different values of the constant a. Janisch (1925) has recently set forth a theory for the explanation of physiological reactions of all kinds, naming the generalization the "Exponential Law" or "Exponentialgesetz." He postulates that the general form of the growth curve is that of a catenary, the special curve formed by any flexible object suspended loosely from the two ends. The catenary has the formula.

$$Y = \frac{a}{2} (e^{x/a} + e^{-x/a}) \quad \ldots\ldots\ldots\ldots \quad (3)$$

and is symmetrical. By substituting a second constant b in place of the second a in the formula an asymmetrical curve is formed, which can be made to approach many types of experimental curves. The general form of equation (3) is similar to that of (2), but the theoretical basis of (2)

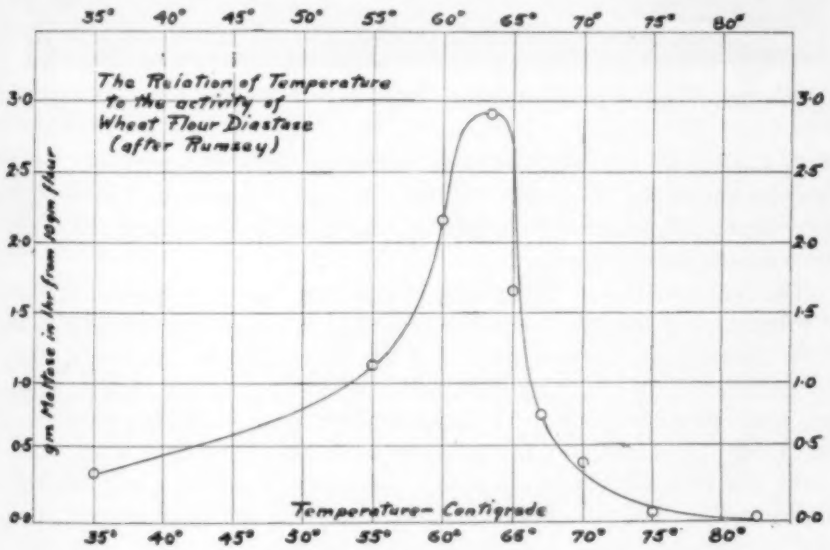

FIG. 31

is more sound, and connects these physiological reactions more closely with chemical theory.

Considering now the influence of time on the rate of metabolism, a similar line of reasoning may be used. A larva taken from a cold room and warmed rapidly might conceivably follow an exponential curve in its rate of metabolism until a point is reached at which a limiting factor,

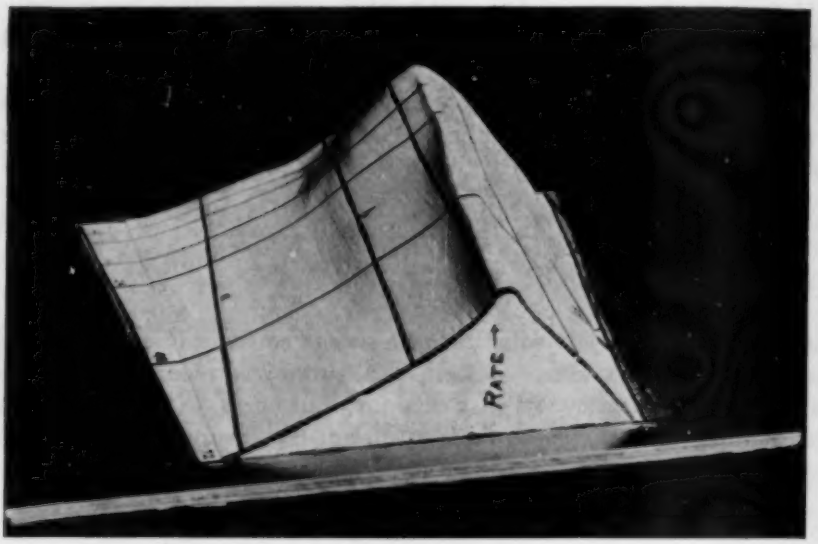

FIG. 32.—Time-temperature-growth. Model for *Chorizagrotis auxiliaris* Grt.

such as disposal of waste products, slows the chain of reactions. This limiting factor would probably follow the same course, and we would have a compound curve somewhat similar to that of equation (2), with time substituted for temperature.

The mathematics of the subject is complex, but it is evident that a combination of the rate, temperature and rate, time curves would give a three-dimensional surface including the three factors rate, time and temperature. In order to show some of the properties of the time-temperature-growth surface, a model has been constructed from the data of Table 4. Time and temperature form the horizontal axes, with metabolic rate as the vertical axis. This model has been photographed in Figure 32. The time scale is shown along the left hand margin, and the temperature scale is along the edge in the foreground, low temperature to the left, and high temperature to the right. The obser-

vations have been smoothed in constructing the model, but no important irregularities were omitted.

Several interesting points are to be noted. The limits in time are (*a*) the theoretical curve for instantaneous exposure, (which is *not* an exponential curve of the van't Hoff type, as expected by Blackman), and (*b*) the curve obtained by holding under constant conditions. Curve *a* starts at the lower thermal death point, and ends at the upper thermal death point. Curve *b* starts at the lowest temperature at which perceptible growth occurs, and ends at the lower limit of heat dormancy or aestivation. The temperature zone between the lower limits of curves *a* and *b* is the zone of dormancy, and that between their upper limits is the zone of aestivation. The point of most rapid metabolism (for this species) lies in the vicinity of 32°C, becoming slightly higher as the exposure time is shortened. The exposure time for most rapid growth *per hour* is about eight hours near 32°, lengthening below this temperature and shortening above. It is very significant that combinations of time and temperature of these approximate values are very common during spring and summer in the temperate zone. Temperatures above 32° are rarely prolonged more than a few hours, while temperatures between 15° and 20° commonly occur for quite long periods. The temperature-time optimum is strongly marked at high temperatures, while at low temperatures the curve is nearly flat, and shows little change with time. Above the zone of most rapid growth the optimum is still marked, but approaches the zero of the time scale, and the fall becomes more rapid until the whole curve disappears at the upper thermal death point.

The surface may be regarded as a direct combination of two sets of curves; the growth/time curves, with a point of most rapid growth for each temperature, and the growth/temperature curves, with a temperature of most rapid growth for each time interval. At the point where these two lines of most rapid growth intersect is the temperature/time optimum, or point of absolute maximum growth. This is the peak of the model.

Summary

Two sets of experiments are presented, which were planned to determine the effects on growth and metabolism of alternating high and low temperatures. One set gives the rate of growth of first instar larvae of *Porosagrotis orthogonia* when exposed to various high temperatures for short periods per day, and the other set gives the rate of carbon dioxide production by nearly mature larvae of *Chorizagrotis auxiliaris*, during similar exposures.

Both experiments point to the same conclusion: In working with temperature it is necessary to consider the time of exposure. They show that larvae removed from a cold room to a warm incubator gradually accelerate their metabolism for several hours, after which their metabolic rate gradually declines over two or three days to a lower constant figure. The combinations of time and temperature which produced most rapid metabolism in the cutworms used were those which are very common in the temperate zone during the growing season.

These results are interpreted as being the resultants of opposing forces. In considering the relation of temperature to metabolism, the two forces concerned may conceivably be the increased activity and increased destruction of enzymes at high temperatures. In considering the relation of time to metabolism, the two forces might be the production of new tissue material and the elimination of waste products. In both cases an equilibrium is reached.

A combination of the time-temperature-metabolism curves gives a three-dimension surface, from which the rate of metabolism or growth for any time-temperature combination may be predicted. This surface has the following properties:

(1) An optimum combination of time and temperature for the given species; a point at which the rate of growth reaches its highest absolute value.

(2) A shift in the time position of the optimum line with changes in temperature, the optimum time being shortened at higher temperatures.

(3) A series of zones of equal growth rate, surrounding the absolute time-temperature optimum. This makes it possible to secure any given growth rate less than the maximum by several combinations of time and temperature.

(4) A correlation of the limits of growth in time and temperature with the zones of dormancy and the thermal death points.

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A PRELIMINARY REPORT ON THE FACTORS CONTROLLING THE OVIPOSITION OF MAY BEETLES IN MINNESOTA
(*PHYLLOPHAGA, SCARABAEIDAE, COLEOPTERA*)[1]

By HARVEY L. SWEETMAN, *Minnesota Agricultural Experiment Station*

INTRODUCTION

Several areas in southern Minnesota suffered from severe outbreaks of white grubs in 1924–25. This paper is a preliminary report of the factors controlling oviposition in Minnesota as determined from the presence of grubs in 1925 and eggs and beetles in 1926.

ANALYSIS OF LITERATURE

The May beetles are a difficult group to study, having a two to four year life cycle and spending all but a few weeks of this time in the soil. This latter brief period of the adult stage is an alternation between life in the soil in the daylight and above soil at night. As a result very few workers have attempted extended studies. The principal publications, dealing with the subject taken up in this paper are by Criddle (1918), Davis (1916, 1918, 1922), and Forbes (1894, 1907, 1916a, 1916b).

Criddle says that May beetles are not found on the treeless plains of Manitoba. He found *P. anxia* an inhabitant of rich lowlands in the vicinity of willow inhabiting areas while *P. drakei* preferred sandy soils in higher and more open situations for breeding places. Regarding oviposition he states: "Grass lands are especially attractive to June beetles for egg laying purposes, and should there be any of these insects in the neighborhood they are sure to be found breeding in such places." No data is given as evidence for his conclusions.

Davis (1916) states: "We know the beetles prefer a ground covered with vegetation for the deposition of their eggs, hence, other conditions being equal, most of the eggs will be laid in timothy, blue grass, and small grains." He further says that "ground which was kept thoroughly cultivated during the flight of the beetles will be comparatively free of eggs." In 1918 he emphasizes that "there are no authentic records of injury to such crops as alfalfa and clover" and also says "the beetles prefer to deposit their eggs in ground covered with vegetation in the immediate vicinity of timber, usually choosing for this purpose the more elevated spots." The 1922 paper is a short summary of previous conclusions and is of interest only as a recent affirmation of former conclusions. Apparently most of his observations regarding places of oviposition are based on the years of injury and thus were made two or three years after the eggs were laid.

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Forbes' papers contain more ecological information dealing with physical factors than others. In 1894 he makes these statements: "It is now well settled that at least some species of the white grubs may be freely and abundantly bred in fields of corn. . . but it still remains true. . . that corn is much more likely to be damaged if planted on sod than if it follows clover, some small grain, or corn itself. We have no evidence that the eggs of the June beetle are ever laid in clover. It is well known that a surface growth of vegetation is a strong attractant to these insects searching for places suitable for the support of the young." In 1907 he says regarding the collection of grubs in 1904 and 1905: "They show that the grubs were more abundant on the higher and drier parts of the country than on lower and moister parts, and that the fewest eggs were laid by the parent beetles in the corn fields and most in grass lands." Later this statement is found: "While the old idea that white-grubs are essentially insects of pastures and meadows has been exploded by observations of recent years, it still remains true that, other things being equal, they are most abundant in grass-lands." In another paper (1916b) Forbes gives data showing the relationship of trees to infestation and the numbers of grubs in various crops. Fallow land was third in numbers of grubs found, but he says this was "grown up of course to weeds, largely grasses." On the next page: "The predominance of grasses and small grains over corn and other crops as a lure to May beetles about to lay their eggs is unmistakable." These conclusions regarding *selection* of fields for egg laying are taken from the *presence* and *survival* of grubs two or three years after the eggs were laid. The writer does not know of any publications giving data to show that the beetles select or that eggs are not laid in fallow land free of vegetation that was made *while the adults were flying*.

Life History

The May beetles of Minnesota emerge in the spring and oviposit in the soil. The eggs hatch in two to four weeks into small grubs that feed upon the roots of the vegetation for two to four years. Then the larvae pupate in the soil from a few inches to two feet deep and transform into adults the same year. They remain as adults in the pupal cell until the following spring. A few species migrate downward in the fall after transformation.

Acknowledgments

Acknowledgments are due Dr. R. N. Chapman, Dr. W. C. Cook, and Prof. A. G. Ruggles of the Department of Entomology at the University of Minnesota and to Prof. J. J. Davis, Head of the Department of Entomology at Purdue University, Lafayette, Indiana.

A SURVEY OF THE WHITE GRUB INFESTATION LUVERNE MINNESOTA IN (1935)

Survey Methods

A survey was made in 1925 of the territory about Luverne, Minnesota, a district having more or less infestation for several years, to determine the influence of local factors and to correlate this with the known facts regarding oviposition. The data were secured from the farmers by personal interview and by making an examination of the fields following the interviews.

Species Present

The principle species concerned were *Phyllophaga fusca, P. implicita, P. rugosa, P. anxia, P. futilis, and P. drakei. P. fusca* requires three years for its life cycle in Kansas (Hayes, 1925) and Illinois (Forbes, 1916a; Davis, 1916); *P. anxia* three in Illinois (Forbes, 1916a) and four in Manitoba (Criddle, 1918); *P. drakei* three in Illinois (Davis, 1916) and four in Manitoba (Criddle, 1918); *P. rugosa* two and three in Kansas (Hayes, 1920); three in Illinois (Davis, 1916), and four in Manitoba (Criddle, 1918); *P. futilis* and *P. implicita* two and three in Kansas (Hayes, 1920) and Illinois (Davis, 1916). It is to be concluded from this that a three year cycle is probably correct for southern Minnesota. If this is true the damage in 1925 was produced by grubs from eggs laid in 1923.

Physical Factors

Crop History. The predominant rotation used by the farmers in this section is corn and oats in alternate years as stated above. Davis (1916, 1918, 1922) and Forbes (1894, 1907, 1916b) state that May beetles do not lay many eggs in cleanly cultivated or clover fields but that they prefer small grains and grass lands. Britton (1912) gives both grass lands and cultivated fields but says that they are more frequent in the former. The survey of 1923 crops at Luverne revealed 54 per cent of the corn fields, 52 per cent of clover fields, 44 per cent of oats fields, 37 per cent of clover-timothy fields, and 0 per cent of grass lands

Table 1. A Summary of the Crop History in 1923 of Fields Showing Infestation in 1925

1923 Crop	Total Acreage	Infested Acreage	Per cent of Infestation
Corn	7818	4193	54
Clover	372	192	52
Oats	5509	2419	44
Clover-timothy	392	147	37
Blue grass	141	0	0
Barley	103	103	100

contained grubs (Table 1). Only three fields of barley were concerned and all had high infestation. The lack of immunity of any crop indicates strongly that selection by the laying females is not an important factor.

ELEVATION AND SLOPE. It was thought that elevation and slope might have some influence, especially in over-wintering, upon the numbers of larvae present. Davis (1918) states that elevated areas containing vegetation are preferred for oviposition. Criddle (1918) lists *P. anxia* as an inhabitant of moist, rich lowlands in Manitoba while *P. rugosa* and *drakei* prefer higher and more elevated situations. Forbes (1907) says that more grubs are always found in high dry fields. In Minnesota upland showed infestation more frequently than lowland but apparently slope did not affect the numbers of grubs found (Table 2).

TABLE 2. A SUMMARY OF THE ELEVATION AND SLOPE OF FIELDS IN RELATION TO GRUB INFESTATION IN 1925

Elevation and Slope	No. of Fields	No. of Infested Fields	Per cent of Infestation
Upland	198	107	54
Lowland	64	22	35
North	37	24	65
South	95	53	56
East	36	19	53
West	30	11	37
Level	64	22	35

SOIL SURFACE FORMATIONS. Soil types classified according to surface formations (Leverett and Sardeson, 1919) were about equally troubled (Table 3). Similar types of soils, rocky and gravelly, had the highest and lowest infestations. Davis (1916) states that most species prefer a clay-loam soil while Criddle (1918) mentions *P. rugosa* and *drakei* as inhabiting sandy soils. Criddle intimates that food plants might be the cause of this apparent selection.

TABLE 3. A SUMMARY OF SOIL SURFACE FORMATIONS OF GRUB INFESTED FIELDS IN 1925

Soil Type	No. of Fields	No. of Infested Fields	Per cent of Infestation
Rocky	72	44	61
Clay loam	99	51	51
Silt loam	164	81	49
Gravelly	84	38	45

RELATION OF FOOD PLANTS TO INFESTATION

Trees are given by Forbes (1907, 1916b), Davis (1916, 1918, 1922), and Criddle (1918) as a very important factor in determining the degree of infestation. Criddle finds that May beetles are absent on the treeless

plains of Manitoba. A study of Table 4 shows that slightly over half of the fields without trees were infested but that two-thirds of the fields within an eighth of a mile of trees were attacked. Nearly three-fourths

TABLE 4. A SUMMARY OF FIELDS INFESTED WITH GRUBS IN 1925 WITH TREES WITHIN ONE-EIGHTH OF A MILE

Tree Data	No. of Fields	No of Infested Fields	Per cent of Infestation
With trees	141	93	66
Without trees	241	122	51
Cottonwood	32	24	75
Ash	29	20	69
Willow	40	26	65
Maple	11	7	64
Boxelder	20	9	45
Miscellaneous	9	7	78

of the non-infested fields, 117 of 167, were over an eighth of a mile from trees. Fields near willow, ash, cottonwood, and maple showed from 64–75 per cent infestation, while those near boxelder dropped down to 45 per cent. This is in accord with studies in 1926 at Jordan, Minnesota when boxelder proved unattractive to the species present. This shows a direct relationship between trees and grub damage but does not explain the high infestation away from trees. Forbes (1916b) has data to show that trees have very little effect beyond one-eighth of a mile. The high infestation away from trees in this region indicates that other plants besides trees are used for food or else flights of more than an eighth of a mile in length on returning to the soil in the morning take place. No evidence of long morning flights beyond this distance have been observed. In the spring of 1926 *P. anxia* was found to be a general feeder on woody and herbaceous plants, although the former were preferred. Probably other species can, if occasion arises, do likewise. Forbes (1907) states: "The discovery that certain species, at least, of the May-beetles may feed, and some do feed to a small extent, on corn and grass, and the consequent conclusion that they may not need convenient access to trees for food, raises the important question whether some of these insects, and possibly certain species of them, may not live continuously in the fields feeding on crop plants there and laying their eggs in the very places where they themselves originated." Hayes (1919) gives a long list of food plants, weeds and grasses, of one species that is independent of trees. Furthermore, Hayes (1920, 1925) in Kansas and Dawson (1922) in Nebraska give data showing the importance of herbaceous plants as food of May beetles.

STUDIES OF OVIPOSITION OF MAY BEETLES

The above survey made it evident that the outbreak in Minnesota could not be understood on the basis of present knowledge of oviposition responses. Trees explained the presence of grubs in many fields but this factor was far from giving a satisfactory explanation for the district. Further studies were undertaken in 1926 to investigate this problem at Jordan, Minnesota.

Species Studies

The species present in sufficient numbers to make careful studies with were *P. implicitia*, *anxia*, *fusca*, and *drakei*. *P. implicita* was the dominant form and the principal one studied. Other species present in fewer numbers were *P. futilis*, *nitida*, and *rugosa*.

Relation of Physical Factors to Oviposition

Factors Influencing Oviposition. According to Davis (1916, 1918, 1922) and Forbes (1894, 1907, 1916b) Phyllophaga do not oviposit to any noticeable extent in cleanly cultivated, alfalfa, or clover fields but prefer grass lands and small grains. Criddle (1918) and Britton (1912) give grasslands as the principal egg beds. No authentic records of injury to alfalfa and clover are known to Davis (1918). The writer found one field of alfalfa near Luverne, Minnesota that showed considerable injury from grubs in 1925. Davis also states that oviposition may occur in corn fields during cold periods when the beetles are unable to fly. A study of the temperature and the precipitation at Luverne in 1923 shows the spring to be drier than normal and unusually hot. The mean temperature in 1923 for May was +3° F. and for June +13° F. The precipitation for May was one inch and for June 2.8 inches below normal.

Egg counts and observations in 1926 of adults in corn, small grains, meadow, timothy, potato, and alfalfa plots were made throughout the season at Jordan, Minnesota. Between May 20 and June 11 twenty-six square feet of corn revealed 59 eggs while very few were found in small grains and grass lands. Because of the dry weather the soil was free of weeds and much of the corn did not sprout until after June 1, thus proving that vegetation is not a direct factor in location of oviposition. Grasses or small grains were within 50 feet of the places where any sample was examined. Beginning on June 26 and once a month thereafter five samples of soil of one square foot each were examined in each of the plots shown in Figure 33 and the data recorded in Tables 5 and 6.

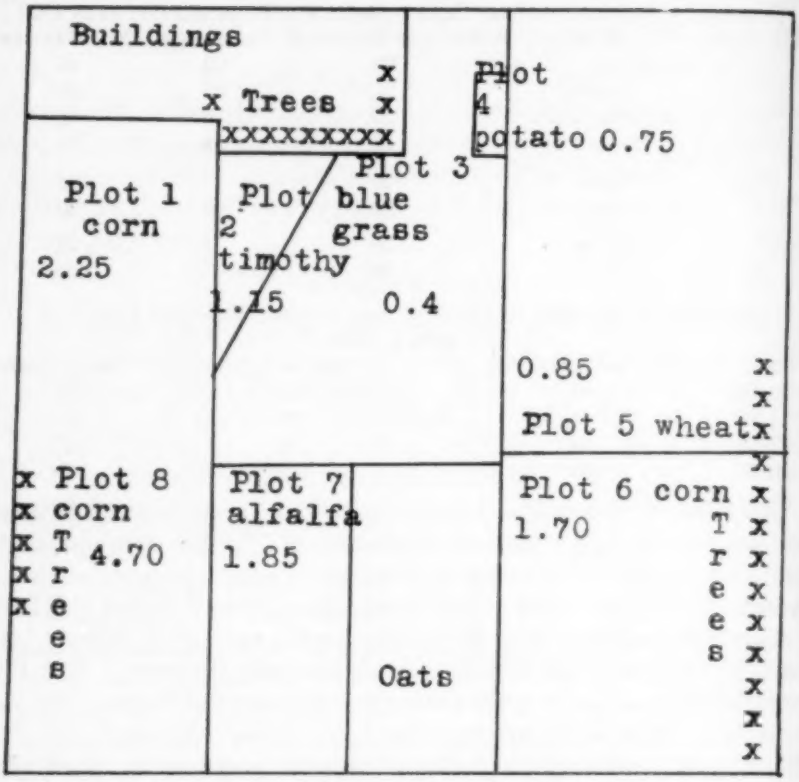
TABLE 5. A SUMMARY OF SOIL EXAMINATIONS FOR EGGS AND GRUBS IN 1926

Plot No.	Crop	Sq. Feet Examined	No. of Eggs	No. of Grubs
1	Corn	20	62	45
2	Timothy	20	31	23
3	Blue Grass	20	0	8
4	Potato	20	18	15
5	Wheat	20	11	17
6	Corn	20	21	34
7	Alfalfa	20	1	37
8	Corn	20	5	94

TABLE 6. A MONTHLY SUMMARY OF SOIL EXAMINATIONS FOR EGGS AND GRUBS IN 1926

Date	Sq. Feet Examined	No. of Eggs	No. of Grubs
6-26-26	40	103	14
7-13-26	40	46	63
8-13-26	40	0	117
9-16-26	40	0	79

Other factors rather than selection were found to account for location and numbers of eggs found. In the season of 1926 the corn and potato land (Fig. 33; Plots 1, 4, 6, and 8) were free of weeds and contained much more moisture than meadow and small grains (Plots 2, 3, and 5). Plots 1–4 are comparable as they all bordered on the same grove of trees. All samples were taken at a uniform distance form the trees. Plot 1 in corn had twice as many grubs as timothy and over five times as many as blue grass. Both of the latter had hard, dry surfaces that the insects had difficulty in penetrating and they were often observed to fly on after failing to dig in. Some crawled 10 to 20 feet before giving up or finding a spot where the crust was broken (often my footprints). Plot 4 was heavily infested with ground beetle larvae which fed upon the grubs, destroying the majority of them before the August count. Plots 5 and 6 were side by side facing another grove. All samples were taken within 10 feet of the border line between the two plots. Again corn had twice as many grubs and eggs as the small grain crop. The wheat field had a loose soil but was very dry which was undoubtedly a reducing factor since the larvae were smaller and lacked the plumpness of those in the moist corn land. It is very doubtful if beetles will oviposit in a very dry soil and if they do the eggs are subjected to severe drying which may destroy them. Plots 7 and 8 are of particular interest as alfalfa is according to Davis (1916, 1918, 1922) and Forbes (1894, 1916b) unfavorable for oviposition. Plot 7 had the most grubs but was slightly nearer the trees. Most of the eggs had hatched when the first counts were made on June 26. The alfalfa land was low and moist enough to harbor the insects.


Buildings
x
x Trees x
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Plot
4
potato 0.75
Plot 3
Plot 1
corn
2.25
Plot
2
blue
grass
timothy
1.15
0.4
0.85
Plot 5 wheat
x
x
x

ber 16 gave a decided reduction. Many of the grubs had started the downward migration on this date and time did not permit deep digging of all samples. The deepest larvae were over 2.5 feet below the surface.

TABLE 7. A SUMMARY OF SOIL EXAMINATIONS FOR GRUBS IN 1926 AT LUVERNE, MINNESOTA

Plot No.	Crop	Sq. Feet Examined	No. of Grubs	Grubs per Sq. Foot
1	Corn	15	9	3
2	Blue grass	10	0	0
3	Corn	20	16	4
4	Corn	10	13	6.5
5	Alfalfa	5	0	0

The influence of soil moisture and hardness of soil upon egg laying may be further illustrated by a study of a farm at Luverne, Minnesota, (Table 7 and Figure 34). In 1926 a large flight of beetles occurred in this area. A careful survey of one farm on September 4–5 was made. Plots 1, 3, and 4 in corn averaged from 3 to 6.5 grubs per square foot, while plots 2 and 5 in pasture and alfalfa were free of grubs. The trees across the road from Plot 1 were largely boxelder while willow and cottonwood were predominant along the other plots. The spring of 1926 was very dry in this section, making the soil in uncultivated plots very hard to penetrate and kept the infestation out.

The type of vegetation may sometimes be a factor in keeping the beetles out. Bent grass, *Agrostis stolonifera*, on a Minneapolis golf green was found to prevent *P. fusca* from burrowing in the sod because of the thick root mat.

Wind is also important as the beetles fly with the wind on returning to the fields in the morning.

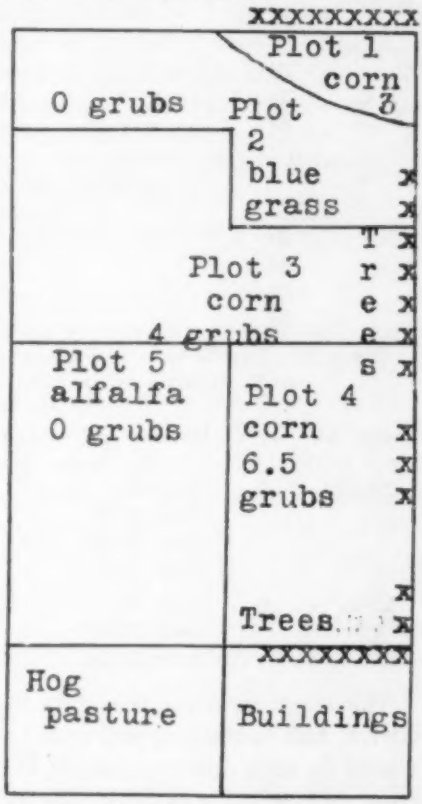

FIG. 34.—Diagram of farm at Luverne, Minnesota, showing arrangements of plots and the number of grubs per square foot.

On May 26 the flight was northward over grass land from the food plants with a wind that was from the south. The wind on June 6 was blowing in a southeastward direction and all beetles flew with the wind into a corn field from the same food plants as on May 26.

DELAYING EGG LAYING. Field observations indicated that the beetles did not select according to the surface covering on their return to the soil in the morning, yet the numbers of eggs and grubs were greatly reduced in these areas. This raised the probability that the females were able to withhold their eggs when in unfavorable places. In order to determine if Phyllophaga could delay egg laying three series of experiments were used (Tables 8, 9, and 10).

TABLE 8. EFFECT OF PRESENCE OR ABSENCE OF SOIL ON OVIPOSITION OF *P. implicita* CONFINED IN SIX OUNCE CANS

Temp. °C.	Soil Present	No. of Eggs
20	yes	15
20	no	0
25	yes	16
25	no	1

TABLE 9. EFFECT OF PRESENCE OR ABSENCE OF SOIL ON OVIPOSITION OF *P. implicita* CONFINED IN CLAY POTS

Temp. °C.	Soil Present	No. of Eggs
20	yes	19
20	no	0
25	yes	49
25	no	4

TABLE 10. THE EFFECTS OF PRESENCE OR ABSENCE OF SOIL ON OVIPOSITION OF *P. implicita* BY ALTERNATIVELY PLACING THEM IN AND ABOVE SOIL

Temp. °C.	No. ♀	Dates in Soil	Eggs When in Soil	Dates Above Soil	Eggs When Above Soil
22–25	5	Aug. 17	2	Aug. 18	0
		Aug. 19–21	5	Aug. 22–23	0
		Aug. 24–27	10	Aug. 28–31	0
		Sept. 1–7	3		
22–25	8	Sept. 10	2	Sept. 11–15	0
		Sept. 16–17	13	Sept. 18–20	1
		Sept. 21–24	8	Sept. 25–29	0

The cages used for this data in Table 7 were six ounce cans with covers, half containing soil and half without soil. Five females were placed in each and maintained at the respective temperatures for 20 days. At 20° C. and 25° C. the females that were laying when the experiment started continued laying in soil but only one egg was laid in the cages without soil. Newly emerged beetles did not start laying in

either case, perhaps because mating was interfered with in the small cages.

Six inch clay pots were used to secure the data recorded in Table 9. Six females were kept in each cage for 20 days. At 20° C. 19 eggs were laid in the cage with soil and none in the one without soil. In the 25° C. pots the results were 49 to 4 favoring the cage with soil. Again it is possible the eggs were destroyed in the cages without soil.

Table 10 gives the results when glass jars containing soil were used. The beetles were allowed freedom in the soil for a few days then screen was placed on top of the soil to prevent them from digging in for a few days. The screen would permit the eggs to pass through if any were laid while above the soil. The first cage in the table shows 20 eggs laid in 15 days in the soil and none in 7 days above the soil. The second cage shows 23 eggs laid in 7 days in the soil and one in 11 days above the soil.

Summing up the data in Tables 7, 8, and 9 show 142 eggs laid in favorable while only 6 were laid in unfavorable conditions. This shows that the adults can delay oviposition in unfavorable conditions. Furthermore, all dead beetles were dissected and some eggs, two of which hatched, were noticeable developed beyond the normal oviposition state. If this is true it is not unreasonable to expect females that find themselves in a very dry soil to withhold eggs until a more favorable condition is found.

Conclusion

The May beetles studied do not select places for oviposition according to the vegetational covering but fly at random from the food plants. Wind is usually not of importance in the evening but influences the direction of flight in the morning. Oviposition is in the immediate vicinity of food plants regardless of the elevation or type of soil when the physical conditions are suitable. If the soil is soft enough to permit digging and sufficient moisture is present the eggs are laid. Egg laying can be delayed at least 5 days when the beetles chance to get into unfavorable places. Probably many eggs and young grubs are destroyed in very dry soils. Cultivated land, as found in corn fields, satisfied the conditions for oviposition in Minnesota in 1926, while the physical conditions in small grains and grass lands did not. The evidence indicates the same conclusion to explain the results from 1923.

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IS GLUTATHIONE THE ARSENIC RECEPTOR IN INSECTS?

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ABSTRACT

This paper deals with the quantitative estimation of glutathione in normal insects and those after treatment with arsenicals of varying dilutions. Preliminary results indicate a variation in the normal glutathione content in different species. Those species subjected to arsenical treatment gave marked reduction in their glutathione content, presumably indicating that glutathione is an arsenical receptor.

Studies on the respiratory metabolism of insects have shown (1) that the normal rates of both the oxygen consumption and carbon dioxide output were greatly reduced (47%–55%) as a result of feeding or injecting with certain arsenicals. If we represent the oxygen intake and carbon dioxide output as ordinates and time in hours as abscissa, we find that the inhibition of the gaseous exchange may be graphically illustrated by a line the slope of which indicates the depression as a result of arsenical treatment (fig. 35). In previous work (2) it was

[1]The writer wishes to acknowledge the assistance rendered in the experimental work by H. Beerman, Field Assistant.

noted that the respiratory metabolism of normal insects decreased with age. In this case the curve (fig. 36) representing the decrease in the

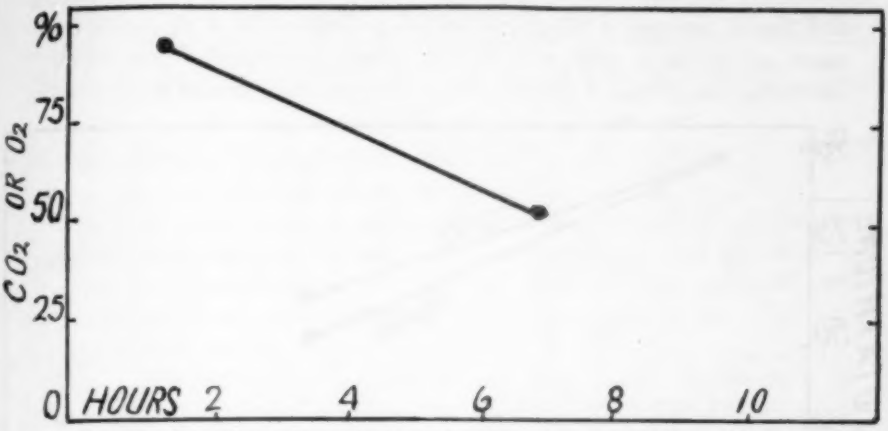

FIG. 35. The effect of arsenicals on the respiratory metabolism of insects.

gaseous exchange is a gradual one declining day by day for several months or more until the death of the insect. It is quite evident from these two illustrations that some substance in the protoplasm which is of great importance in the function of cell respiration, and normally is specifically concerned in a chemical defense of the body, is influenced by certain poisons. In one case (fig. 35) it is caused by the introduction of an external poison like arsenic in the body of the insect and in the other (fig. 36) by toxic substances probably produced within the body of the insect itself.

Several theories have been suggested to account for the mechanism concerned in cell reduction and oxidation. Nearly all animal tissues have the property of reducing sulphur to hydrogen sulphide, and the view maintained by Heffter (4) and others, is that the unstable hydrogen in the sulphydryl group - SH of living cells has important respiratory functions. Heffter, furthermore, applied the nitroprusside test to a large number of animal tissues and obtained a positive reaction which led him to suggest that the hydrogen of the - SH group was responsible, in part at least, for the reducing properties of protoplasm. He further suggested that in the cell some substance might act as an acceptor for the oxygen of the water molecule, leaving the hydrogen to reduce the disulphid group once more to the sulphydryl group, as in the following reaction,

$$SH—HS- \rightleftharpoons -S\text{-}S - + H_2$$

According to Hopkins (5) this reversible reaction brought about by factors present in the cell itself has dynamic functions. Hopkins began a study of the substance responsible for the nitroprusside test in tissues and finally isolated a substance which proved to be a dipeptide composed of glutamic acid and cystein which he named "glutathione." According to Hopkins glutathione is responsible for the nitroprusside

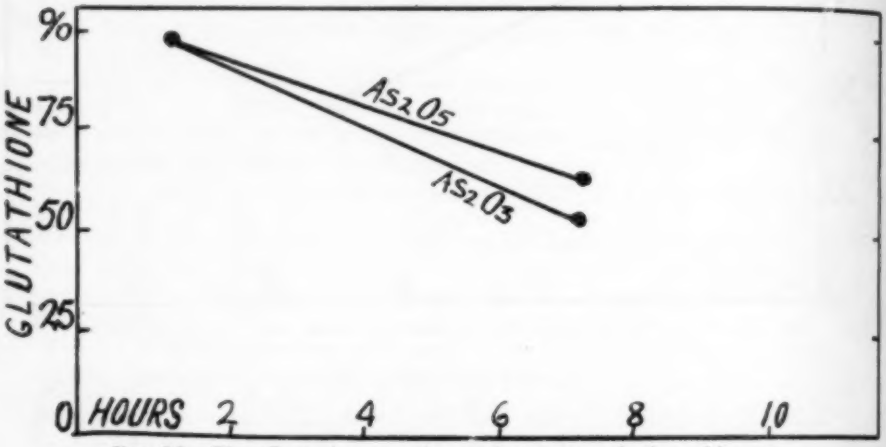

FIG. 36. The effect of age on the respiratory metabolism of insects.

reaction which is given by nearly all animal tissues and contains practically the whole of the non-protein, organically-bound sulphur of the cell. Glutathione acts readily under varying conditions as either a hydrogen or an oxygen acceptor. It can be both reduced and oxidized under the influence of factors shown to be present in the tissues.

That glutathione is of importance in the oxidation and reduction of cell respiration, Hopkins proved by the following experiment. Fresh tissue was thoroughly washed and boiled in water for several hours for the purpose of extracting all the glutathione. The residual tissue was afterwards dried, ground into a powder and placed in a Barcroft manometer, where it was determined that practically no respiration took place. However, if a little of this powder suspended in a dilute solution of glutathione was placed in a manometer, the material began to take up oxygen and give off carbon dioxide comparable to fresh tissue. This was experimental proof of the importance of glutathione in cell respiration.

In view of the inhibiting effect of arsenicals upon the respiratory metabolism of insects determined by the writer (1), it seemed worth while to test experimentally the effect of arsenicals upon the glutathione

content of insects. Among entomologists the opinion maintained is that different species of insects vary in their resistance to arsenicals. If that is true, it was reasoned, a greater glutathione content should be found in those species. It seemed desirable to determine this point as a clue to the presence of a receptor for arsenic in insect protoplasm.

Methods of Determining Glutathione

Two methods of determining the presence of glutathione in insects were used; one was qualitative, the other quantitative.

The qualitative was a micro method devised by the writer for the purpose of determining by aid of the nitroprusside test the relative distribution of glutathione in the tissues and organs of single insects. This method is described in Science (3) and the reader is referred to this article for further details.

The quantitative method for determining the actual amount of glutathione per gram tissue was described by Tunnicliffe (6) for yeast and animal tissue and was adopted for insect material.

Quantitative Method of Determining Glutathione

The tissue to be examined for glutathione is weighed and ground up with a little sand in a 10 per cent trichloracetic acid solution. After several hours it is filtered and the residue re-extracted several times with further amounts of the acid. The filtrates are combined, and an aliquot portion is used for titration with a 0.01N iodine solution, using several drops of a 5 per cent sodium nitroprusside solution or 0.5 per cent starch solution as an external indicator. Tunnicliffe found that 1 cc. of a 0.01N iodine solution was equivalent to 2.5 milligrams of glutathione; hence if one knows the amount of iodine required as a result of titrating the trichloracetic acid extract obtained from the tissue, it is possible from such data to calculate the amount of glutathione contained in one gram of tissue.

Trichloracetic acid, according to Tunnicliffe, gives an extract free from protein; does not precipitate glutathione or interfere with subsequent iodine titrations; and finally, owing to the acidity of the solution, the glutathione is not oxidized but remains in the reduced form as found in the tissue.

The Extraction of Glutathione From Insect Tissue. In normal animals 1 to 2 milligrams of glutathione is usually obtained per gram of tissue, and it is necessary to have at least 5 to 10 grams of tissue for a test. Insects, however, are particularly difficult material in which to determine glutathione owing to the presence of large amounts of chitin

and varying amounts of water to be taken into consideration when different stages of a species are used for comparison. It is essential, therefore, to use a large number of insects (50 to 100), depending upon the size of the species and the chitin content, in order to obtain 5 grams of tissue.

The approximate chitin content for each species is determined by first weighing a certain number of insects (50), dissecting and separating the tissue from the chitin, weighing the latter and calculating the per cent chitin present for each sex. Similarly the water content is determined by weighing a certain number of insects and afterwards dehydrating, and from the loss in weight obtained calculating the per cent of water for the species.

Experimental Procedure. To quantitatively determine glutathione the insects of a species under investigation are separated into sexes and left without food for several hours for the purpose of clearing the alimentary tract of as much waste and food material as is possible. From 50 to 100 insects of each sex are weighed on a balance to four decimals, afterwards cut up with a fine scissors and placed in a mortar with a little sand and about 10 cc. of a 10 per cent solution of trichloracetic acid, thoroughly ground up. Further amounts of the acid (20 cc.) are added and left for several hours in a stoppered flask to extract the glutathione. The material is then filtered and the residue re-extracted with additional amount of the acid (15 cc.), filtered again, and the combined filtrates are labelled for each species and sex. To determine the amount of glutathione, an aliquot portion (5 cc.) of the sample is drawn out by means of a fine pipette and placed in a beaker, to which are added several drops of a 5 per cent solution of sodium nitroprusside or 0.5 per cent solution of starch; this is titrated with 0.01N or 0.001N iodine solution.

The stock 0.1N iodine solution must be carefully prepared, standardized against the same strength of sodium thiosulphate, and the latter checked against a standard solution of potassium bichromate. The dilute iodine solution should be prepared in a 1 per cent solution of potassium iodide; since these solutions do not keep very long it is essential to prepare a fresh solution every day and to check against thiosulphate and potassium bichromate as above. For calculating the amount of glutathione per gram tissue present in a sample of extract, a typical example is shown.

Weight of 50 insects	13	grams
Weight of chitin (25%)	3.25	"
Water content (50%)	4.87	"
Actual weight of tissue	4.88	"
Trichloracetic acid used	45	cc.

5 cc. filtrate required 0.27 cc. 0.01 N iodine,
Hence 45 cc. filtrate required 9 x 0.27 = 2.43 cc. iodine.
Since 1 cc. 0.01N I_2 = 2.5 milligrams glutathione,
Hence 2.5 x 2.43 divided by 4.88 (wt. of tissue) = 1.24 mg. of glutathione per gram of tissue.

THE EFFECT OF ARSENICALS UPON THE GLUTATHIONE CONTENT. To determine the effect of arsenical dilutions upon the glutathione content it was necessary to feed or inject insects with a definite amount of neutral arsenic solution and after an interval of time determine the effect on the glutathione content. This was accomplished in the following manner. From 800 to 1,600 individuals of a species were separated into sexes, divided into lots of 50 for each sex, left without food for several hours, and weighed on a balance to four decimals. Usually four of the lots (2 lots of ♂'s and 2 lots of ♀'s) were used as controls and were injected with a 1/50 cc. of a 0.7 per cent saline solution. The remaining lots were injected with varying dilutions of arsenic acid or arsenious acid (0.00495 & 0.000495 grams per cc.), using 1/50 cc. for each insect. After injection, the insects were left for 3 to 5 hours for the solutions to become effective, and were afterwards ground with sand and trichloracetic acid as previously described, and samples drawn for titration with iodine.

In Table 1 the data obtained from 15,000 individuals belonging to 10 species were averaged and summarized to show the normal glutathione content for each species and the reduction in percentage due to arsenical treatment. It is readily observed from this table that the normal glutathione content and reduction due to arsenicals vary with the species. If we average the per cent reduction in glutathione for all the species we obtain the following figures. A reduction of 46 per cent due to 0.1N As_2O_3; a reduction of 36 per cent due to 0.01N As_2O_3; a reduction of 37 per cent due to 0.1N As_2O_5; a reduction of 28 per cent due to 0.01N As_2O_5. Or an average reduction of 41 and 32 per cent due to As_2O_3 and As_2O_5 respectively. (Fig. 37).

DISCUSSION. This preliminary study has shown considerable variation to exist in the normal glutathione content of insects. From the present state of the investigation it is impossible to definitely confirm or refute the possibility of a specific resistance towards arsenic to exist in some species. From Table 1 it is seen that *Malacosoma americana* Fab.,

usually considered resistant towards arsenic, contains a considerably lower amount of glutathione as compared with other species. That the variation might be due to factors, such as food and waste material in the alimentary tract, only imperfectly controlled is quite possible.

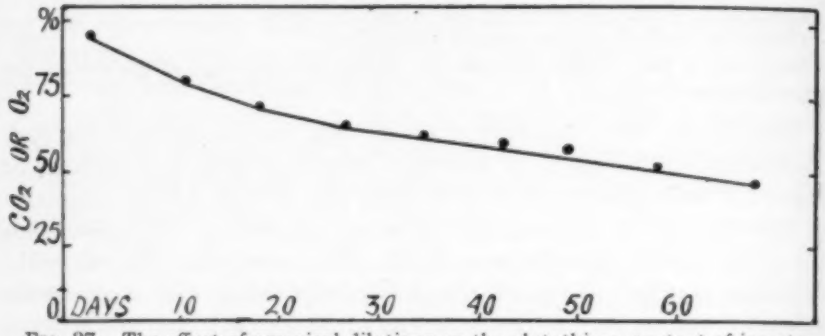

FIG. 37. The effect of arsenical dilutions on the glutathione content of insects.

The ideal method, to deal with separate organs and tissues, appears out of the question with insects.

There undoubtedly is also a quantitative difference in the method of disposal of the arsenic, which may be due to differences in rate of oxidation and excretion of the arsenic. Furthermore, whether arsenic reacts only with glutathione or perhaps also with other cell constituents remains to be determined. According to Voegtlin (7), arsenic may be considered as a specific poison for reduced glutathione, or the toxic action of arsenic may be due to an interference with the normal function-

THE GLUTATHIONE CONTENT

Species	Normal Content	Reduction After Treatment with Arsenicals			
		As_2O_3		As_2O_5	
		0.1N	0.01N	0.1N	0.01N
Leptinotarsa decemlineata	1.59 mg.	38%	28%	28%	28%
Do. Larvae	1.33 mg.	34%	37%	27%	25%
Popillia japonica	1.16 mg.	30%	24%	25%	17%
Do. Larvae	0.81 mg.	35%	28%	35%	27%
Tenebrio molitor (larvae)	1.1 mg.				
Pheletes agonous (larvae)	0.80 mg.				
Pieris rapae (larvae)	0.52 mg.				
Anasa tristis	0.45 mg.	64%	32%	49%	21%
Melanoplus differentialis	0.44 mg.				
Melanoplus femur-rubrum	0.30 mg.	30%	24%	23%	18%
Cotinis nitida	0.36 mg.				
Malacosoma americana (larvae)	0.18 mg.	81%	78%	77%	63%

ing of glutathione in oxidation reduction phenomena of tissues. The fact that glutathione is easily soluble in water makes it readily available for combination with arsenic, and the arsenic, through chemical affinity for the -SH group of reduced glutathione, inhibits the progress of oxidation and reduction in the cell.

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AN IMPROVED CARBON DISULFIDE EMULSION FOR THE CONTROL OF LARVAE OF THE JAPANESE BEETLE AND OTHER INSECTS[1]

By J. WILLIAM LIPP, *Assistant Entomologist, United States Department of Agriculture*

ABSTRACT

A carbon disulfide emulsion has been prepared in which rosin, C. P. sodium hydroxide and U. S. P. oleic acid are used to form the emulsifying agent. In this way variation in the composition of the emulsifying agent is cut to a minimum. At present this emulsion is the one recommended for the treatment of turf and of nursery stock for the control of Japanese beetle larvae. This emulsion has also given good results against the larvae of the Asiatic beetle, *Anomala orientalis* Waterh., and of the green June beetle, *Cotinus nitida*.

INTRODUCTION

During the last few years emulsified carbon disulfide has been used extensively for the control of the larva of the Japanese beetle. With the view of obtaining a formula which would be satisfactory from

[1]Contribution No. 31 from the Japanese Beetle Laboratory, Riverton, N. J. The author wishes to express his thanks to Mr. B. R. Leach for his suggestions and criticisms during the course of this work.

the standpoints of both toxicity to the larva and lack of injury to the vegetation involved in the treatment, many emulsions (*2*, *4*, *5*)[2] were prepared and tested.

Of these the most satisfactory, prior to the fall of 1925, was the one prepared by Leach and Johnson (*5*) having the formula:—Carbon disulfide 10 parts, water 3 parts and rosin fish-oil soap 1 part.

Unfortunately this emulsion stratified[3] very readily (Pl. 19,C), and thus necessitated agitation of the container in order to re-establish homogeneity of the contents. Since the emulsion is usually stored in 500 pound drums, the difficulty of agitating the container is obvious. Furthermore, the emulsifying power of the soap was uncertain on account of the variation in the composition of different batches of the commercial product.

Laboratory Work

With the above-mentioned material as a background, work was begun to prepare an emulsion which would have the desirable features of the old emulsion and be free of its disadvantages. This new emulsion should contain approximately the same percentage of carbon disulfide as the original emulsion in order to avoid the necessity of changing the dosages previously recommended. The emulsion should stratify as little as possible in order to eliminate the necessity of shaking the container to make the contents homogeneous. The emulsifying agent should be made from pure, standard materials, so as to cut to a minimum the variation in composition of the emulsifying agent and, consequently, the possibility of incomplete emulsification or breaking.[4]

In the preliminary experiments, solutions of sodium oleate (containing excess of alkali or acid) were used as emulsifying agents. These were made from U. S. P. oleic acid and C. P. sodium hydroxide (96–98% NaOH). As a result of these experiments an emulsion[5] containing 71% carbon disulfide was produced which, when allowed to stand in a glass cylinder, showed very little evidence of stratification. In addition, it appeared to dilute readily with water, but when the hands were

[2]Italic numbers in parentheses refer to References.

[3]The author has used the term "stratify" to indicate the formation of an upper aqueous layer. In this condition the carbon disulfide is still emulsified and can be diluted with water. By "break" is meant the formation of a lower layer of carbon disulfide, i. e., a separation of the emulsion into its component parts (Pl. 19, D). When this condition occurs, the mixture cannot be diluted with water.

[4]See footnote (3).

[5]The formula of this emulsion was: 472 cc. of carbon disulfide, 16 cc. of oleic acid and 173 cc. of N/5 alkali solution.

Fig. A. A sample of the new emulsion immediately after preparation.
Fig. B. A sample of the new emulsion after standing four months.
Fig. C. A sample of the rosin Fish-oil soap emulsion after standing four months.
Fig. D. An example of a broken emulsion with bottom layer of carbon disulfide.

immersed in this emulsion, diluted to the strength used under field conditions, a slight burning sensation was experienced. This seemed to indicate that the interface surrounding the minute carbon disulfide globule was capable of being ruptured rather readily, permitting the release of some of the emulsified material. It seemed unwise, therefore, to use this emulsion for field work on account of its probable destructive action on tender vegetation. Furthermore, this emulsion could be made only by mixing the oleic acid and the alkali and adding the carbon disulfide gradually to the soap solution and shaking after each addition. Not only was this undesirable from the commercial standpoint, but was likely to increase the cost of the final product on account of the additional labor involved.

Inasmuch as the soap used in Leach and Johnson's emulsion was partly a resinate, several mixtures of sodium oleate and resinate were prepared. The rosin and oleic acid in varying proportions were ground together in a mortar, and varying quantities of a 20% NaOH solution added and ground in. With these different soaps a series of emulsions was prepared, each emulsion containing 1 part soap, 2 parts water and 7 parts carbon disulfide. (70% carbon disulfide as compared with 71.4% in the old emulsion.) All these emulsions were very viscous. By dissolving the soaps in varying amounts of water several soap solutions were obtained which, when used in the ratio of 3 parts soap solution to 7 parts carbon disulfide, produced very satisfactory emulsions.

The formula chosen for the soap solution was:—50 grams rosin, 50 cc. oleic acid, 135 cc. 7% NaOH solution and 450 cc. water. On a large scale the equivalent of this formula[6] is:—9.5 pounds C. P. (96–98%) NaOH, 50 pounds lump rosin, 6 gallons U. S. P. oleic acid and 70 gallons water. (In factory practice it is customary to start with 10% more of each ingredient to allow for losses in handling.)

In preparing this soap solution the rosin should be pulverized and added gradually to the alkali solution (previously warmed). The water should now be added hot and the resulting mixture agitated until the rosin has dissolved. The oleic acid should be added next and the mixture again agitated. This soap solution should then be allowed to cool, but should be re-agitated before being used. If desired, this solution may be prepared in the cold, but much more time is necessary to effect the solution of the rosin in the alkali.

[6]An examination of this formula will show that the amount of sodium hydroxide used is not sufficient to form a neutral soap. This was done purposely, since the addition of too much alkali to the soil is undesirable, particularly in the case of the lawn grasses which require an acid soil for proper growth.

In the preparation of the emulsion 3 parts of soap solution and 7 parts of carbon disulfide should be agitated thoroughly until emulsification results. This point is reached when the contents of the container show a creamy white color (Pl. 19, A) and become quite viscous. A better test for emulsification is made by diluting a sample of the product with an equal volume of water. When diluted in this way the emulsion should show no signs of breaking, if properly made.

Control of Japanese Beetle Larvae

Field tests have shown that this emulsion compares favorably with the rosin fish-oil emulsion previously used. During the past two turf-treating seasons the new emulsion has been used and has given a satisfactory control of the Japanese beetle larvae without injury to the turf, except in places where the grass roots have been weakened by the feeding larvae prior to treatment. The present recommendations for the treatment of lawns and golf greens and of nursery stock (*6*) include the use of this emulsion.

Samples of this emulsion placed in tall cylinders showed no appreciable stratification except after long standing (Pl. 19, B). Under field conditions the container will necessarily be agitated every time a sample of the stock emulsion is used, so that a large stratification will never occur unless treatment is discontinued for a long period.

Low temperatures tend to cause this emulsion to become very viscous, and thus pouring and measuring, especially of small quantities, are rendered difficult. This disadvantage is encountered only in the case of early Spring and late Fall treating of nursery stock, since turf treating is carried on in the warmer weather.

The Control of Other Insects

At the Riverton Country Club and other clubs in the vicinity of Philadelphia this emulsion has been used successfully for the control of the larvae of the green June beetle, *Cotinus nitida*, and other white grubs. The habit of the June beetle larvae of making large entrance and exit holes in the turf, while very destructive and annoying, particularly on account of the mounds of soil thrown up, offers a very ready means of attack. If the holes are left open and the carbon disulfide emulsion is applied to the turf as recommended for the control of the Japanese beetle larvae, very satisfactory results can be obtained.

At New Haven, Conn., this emulsion has been used for the control of the larvae of the Asiatic beetle, *Anomala orientalis* Waterh, (*1*, *3*).

During the year 1926, nineteen tons of this emulsion were used in turf treatments for this pest.

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TWO SPECIES OF THRIPS[1] INJURIOUS TO APPLES IN THE PACIFIC NORTHWEST

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ABSTRACT

So-called Pansy spot or thrips injury on apples is caused by the egg laying punctures of two species of thrips: *Frankliniella occidentalis* and *Aeolothrips fasciatus*. Injury of this character produced by thrips has been reported from most of the apple growing sections of the Pacific Northwest. In some instances the grade of the fruit has been lowered fully twenty per cent.

Pansy spot derives its name from the shape of a discolored area which develops about the egg punctures. The color of this pansy shaped spot varies from white through various shades of pink. Egg laying begins shortly after bloom time, continuing until the fruit has reached the size of large walnuts. The life history of the insect in the orchard is not fully known. Sprays of oil and Black leaf applied while the trees were in full bloom showed that injury can be materially reduced but do not give complete control. The Black Leaf appears to be the active ingredient in bringing about this benefit.

So called "Pansy Spot" or thrips injury on apples proved to be one of the outstanding insect injuries occurring in this fruit in several sections of the Pacific Northwest during 1926. This was particularly true in the Hood River Valley where the damage was general throughout the district. In former years, injury for the most part has been confined largely to orchards in the higher elevations. During the past season

[1] *Frankliniella occidentalis* and *Aeolothrips fasciatus*.

the insects were reported occurring in the Southern Oregon districts, Western Oregon, White Salmon (Wash.), Yakima, Wenatchee and to a lesser extent than usual in the Okanagan (B. C.) orchards. In the Hood River Valley it is estimated that this insect lowered the grade of fruit fully 20%.

Pansy Spot[2] is a term employed to describe the injury resulting from egg punctures of two species of thrips. The development of these spots and the extent of injury varies with the different variety of apple. These are particularly noticeable on such apples as the Northern Spy, MacIntosh, Transparent and, to a less extent, in other varieties grown in this section. From a very small russetted spot, or egg puncture develops a whitish or pinkish area closely resembling a small pansy in outline and color. The affected area is usually lighter colored than the ground color of the injured fruit and is therefore conspicious. Pansy Spots do not develop in all cases of puncturing, often a high percentage do not. The injury is very minute at the time of deposition. This rupture, however, expands with the growth of the apple forming russetted spots of variable size (Pl. 20, fig. 1).

Where numerous, the grade of fruit is materially lowered. Often times the Pansy Spot shows on these varieties during the early part of the season, largely disappearing as the season advances. In such cases usually a small whitish area persists about the punctures or none at all. (Pl. 20, fig. 1.)

At least two species of thrips are involved. During the spring of 1924, two species were taken in the act of oviposition. Apples at the time were about the size of small walnuts. These were sent to Professor J. R. Watson, who writes as follows:

"The smaller, lighter colored thrips is *Frankliniella occidentalis*. The large black insect is *Aeolothrips fasciatus*. It is perhaps a distinct variety of the latter species as it differs in some respects from our eastern species. The most conspicuous difference is that the white area in the middle of the front wing does not extend clear across it but only makes a notch out of the wing. This is true of all three specimens you sent. I wish you would look over your specimens and see if this is true of all of them. If so it would merit our calling the insect a new variety.

Aeolothrips fasciatus is supposed to be predacious and my guess is that you will find this species is feeding on the other. However, this is only a suggestion for your attention and you can work it out on the

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[2]Venables, E. P. Proc. Ent. Soc. B. C., No. 22, 1925.

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2

1 Pansy spots and russet spots on Newtown developing from egg punctures of thrips (Original)

2 Russet developing on Newtown as result of spraying in full bloom and calyx with Dormoil 3–100 (Original)

grounds. I shall be glad to hear further what you can find out about the relation of the two."

The life history and habits so far as their occurrence in the apple orchards of the West are little known. Venables[2] reports finding eggs of thrips in considerable numbers in the flower parts at and shortly after blossom time. Both species have been observed in the flowers at this time in the Hood River district. Egg laying doubtless begins during this period though this has not been actually noted, the first observations being made a short time after the flower parts had dropped. Egg laying continues until the fruit reaches an inch or an inch and half in diameter. Shortly after the fruit reaches this size thrips are found on the trees with difficulty. During May, 1925, the larger of the two species—*Aeolothrips fasciatus*, was found depositing eggs in the midribs of apples leaves, this deposition appeared to be more extensive than in the fruit itself. During the spring, larval thrips can be found on the foliage, their presence, however, does not seem to be associated with injury to the plant. The larva of *A. fasciatus* seem to be more numerous than *F. occidentalis*. The former is probably a predacious species while the latter probably drops to cover crops or weeds to complete its growth.

TABLE 1. THRIPS CONTROL ON APPLES, 1924–1925, HOOD RIVER, OREGON

Exp. No.	Spray Date	Material Used	Apples Counted	Egg Punctures on Apples: 3 or more	Less than 3	Total	% Injured	% Spray Injury
1924	May 10	Oil[1] 3–100						
B-2	(full bloom)	Bl. 40 1 pt–100						
			1003	53	194	247	24.6	13.2
	May 15	Same plus						
	(calyx)	Ars. L. 2–100						
B-2a.	May 15	Oil 3–100						
	(calyx	Bl. 40 1 pt–100	1063	127	328	455	42.8	9.2
	only)	Ars. L. 2–100						
Check		No spray	1095	227	415	642	58.6	0
1925	May 5	Oil[2] 3–100						
B-1	May 16	Oil[2] 3–100	1021	54	230	284	27.8	0
		Ars. L. 2–100						
B-2	May 5	Oil 3–100						
	(full bloom)	Bl. 40 1 pt–100						
	May 16	Oil 3–100	1000	12	133	145	14.5	0
		Bl. 40 1 pt–100						
		Ars. L. 2–100						
Check	No spray	No spray	1009	32	292	324	32.1	0

[1]Dormoil, Hood River Spray Company, used in tests of 1924.
[2]Triona, Balfour Guthrie Company, used in tests of 1925.

Venables reports leguminous crops favorable to the development of *F. occidentalis* where in parts of British Columbia it seriously affects alfalfa seed production. Cover crops, their choice and management, may prove to be a factor in controlling the pest.

During 1924 and 1925 some spraying tests were applied to determine effects on control. In 1924 two tests were applied to determine whether a spray applied in full bloom and shortly thereafter would be of benefit in reducing the injury to fruit. Experiment B-2 (Table 1) consisted of Dormoil 3–100, Black Leaf 40, 1 pint to 100 gallons. The trees were sprayed in full bloom. This formula was repeated as soon as the petals fell. A block of trees (Exp. B 2a) not sprayed in full bloom was sprayed in the calyx with this formula. Some injury to the petals was noted in B-2, many of these turned brown shortly after the spray was applied. A good crop of fruit set, however. The results obtained in these tests are tabulated in Table 1.

Though control was not obtained the results proved that egg laying was noticeably reduced. The full bloom and calyx application reduced the injury more than 50% although 24.6 of the apples showed some injury where the two applications were made. 42.8% injury developed where the calyx spray only was applied, 58.6% in the unsprayed checks. The oil used in these tests was of the dormant type and the fruit showed the effect of the spray at harvest time. (Pl. 20, fig. 2).

The work was continued in 1925, Triona oil being substituted for the Dormoil. The oil was used alone and in combination with Black Leaf 40 (Exp. B-1 and B-2, 1925). A third test in which Black Leaf 40 alone was applied. This experiment was overlooked at the time the results were tabulated and the data relative to its effectiveness were lost. Observations made during the summer indicated the results to be about as found in B-2, 1925.

Infestation was much less severe in 1925. The unsprayed trees developed 32.1% affected fruit, of which but 3% showed more than three egg scars. In 1924 approximately 20% of this type of injury occurred. As in 1924 injury was reduced approximately 50% where the full bloom and calyx spray were applied with oil and Black Leaf 40. The oil alone was not effective.

Thorough discing or plowing before blooming is recommended as a possible aid in the destruction of overwintering insects. Even though present known sprays are only partially effective, applications would be advisable under such conditions of infestation as prevailed in the Hood River Valley during 1926.

A EUROPEAN NITIDULID, *BRACHYPTEROLUS PULICARIUS* L. (COLEOPTERA, FAMILY NITIDULIDAE).

By G. E. R. Hervey

Abstract

This small black nitidulid beetle was probably introduced into this country from Europe quite recently. The adults feed in the blossoms of a variety of plants, including strawberry. It seems doubtful that they cause any injury to the latter. They breed only in *Linaria vulgaris*. As far as is known there is only one generation a year.

During the latter part of May 1924 a small black beetle was observed on strawberry plants in Dutchess County, N. Y. This insect was sent to the Department of Entomology at Cornell for identification and it proved to be *Brachypterolus pulicarius* Linn., a recently introduced nitidulid. The following observations were made the summer of 1925. The object of the study being to determine whether the feeding of this insect in strawberry blossoms caused any injury.

This insect was first described by Linnaeus in 1758 in the tenth edition of his "Systema Natura." He called it *Dermestis pulicarius* and stated that it was found in flowers. Later, in 1788, in the thirteenth edition of the above work he changed the generic name to Silpha. Apparently the species is rather widely distributed in Europe and it has been called a rather large array of names by various European writers. A complete list of the synonomy is given by Grouvelle, 1913.

In America the species was first mentioned about 1919. At this time specimens were sent to the United States National Museum from Youngstown, N. Y., for identification. In 1920 Notman described what Schwarz considers as this species under the name of *Heterostomus mordelloides* from Schoharie County, N. Y. Britton states that in 1921 specimens were collected on the grounds of the Arnold Aboretum near Boston. In the same year a single specimen was taken at Milford, Connecticut. In 1922 Dr. Felt reported this insect from the following Counties in New York State: Columbia, Saratoga, Albany, Niagara and Schoharie. Since 1924 the writer has collected and received specimens from Dutchess, Greene, Genesee, and Tompkins Counties in New York State. Apparently the species is more common in the Hudson River Valley than in any other part of the state.

The most common food plants of this beetle in Europe appear to be *Linaria vulgaris*, common toad flax or butter and eggs, and other species of this genus. The following food plants have been listed by different European writers: *Linaria vulgaris*, *L. supina*, *L. striata*, *Galium mollugo* and *Spiraea ulmaria*. In America Hatch reports in the

Cranberry Lake Coleoptera that the adults were collected in large numbers on dandelions The adults have been observed by the writer on the blossoms of strawberry, dandelion, wild mustard, clover, apple, panicled dogwood, and toad flax. As far as is known the insect only breeds in *Linaria vulgaris* and this also seems to be, by far, the favorite food plant of the adult.

In 1922 Dr. Felt called attention to this insect in the insect pest survey bulletin and stated that it has been injurious to recently opened strawberry blossoms in Southern Columbia County, N. Y. He stated further that the injury was due to the adults feeding on the developing anthers and adjacent tissue causing "nubbins" and blasted blossoms.

Blasted blossoms and nubbins are due to a variety of causes and it might be well to enumerate some of them here. Prof. Oskamp of the Department of Pomology at Cornell states that blasted blossoms and nubbins are largely due to frosts and imperfect fertilization. According to Chandler in his book on fruit growing "if a considerable number of the pistils are sterile an irregular shaped berry will be produced, such as may be produced as a result of injury to the berry from insect punctures." Fletcher in his book on strawberry growing gives the following cause of nubbins: imperfect pollination, injury to the pistils, winter injury, and the work of weevils and other insects. Nubbins are more abundant late in the ripening season when the pollen supply is likely to be short and the plants somewhat exhausted. In another chapter the same writer discusses "buttoning" which is apparently another form of malformed berry. The causes of this trouble are frost, punctures of the tarnished plant bug, dry weather and insufficient nourishment. He states that frost injury is confined to the pistils which turn black when affected. A light frost merely touches the apex of the cone of pistils causing the berry to button.

Observations made the summer of 1925 show that the beetles feed in the strawberry blossom during the whole period of blooming which lasts approximately a month. However, during the latter part of this period their numbers on this plant are relatively much fewer because many of them have migrated to the blossoms of other plants. Numerous blossoms in which the beetles had been feeding were examined and it was found that small areas had been eaten out of the base of the stamens. In most cases it was slight enough to be hardly noticeable. Whether this injury is sufficient to affect the berry has not been definitely established but it seems doubtful that it would be. From the literature examined it seems that malformed berries are due to injury to the pistils

by frost or some other agency. In the case of the blossoms examined none showed any injury to these parts. Blasted blossoms in 1925 were very common in practically every planting, even where the beetles were not present, but it is thought that this was due to frosts during the period of blooming.

A relatively small amount of information on the life history of this species was gained from the literature. Cornelius, in Germany in 1863, made some observations and worked out the life history in some detail. He also gave a description of the larva and pupa. Kaltenbach, in 1874, observed the larvae feeding first upon the pollen and later upon the seed capsule of toad flax. He stated that they transform in the soil around the plant and emerge as adults in September.

In 1925 the adults were first observed on May 6th. They were quite numerous at this time in several strawberry plantings in Dutchess County. Observations made up to May 15th showed them to be confined entirely to this plant. After this date they were found in the blossoms of a variety of plants, such as dandelion, wild mustard, panicled dogwood and the terminal shoots of *L. vulgaris*. The beetles were mating on June 27th. At this time they were feeding entirely on *L. vulgaris* which was just beginning to come into bloom. The first eggs were found on July 20th. They are laid in the unopened bud of *L. vulgaris* and just under the corolla. Usually only one egg is laid in a bud but in some cases as many as three are found. Larvae were found on July 23rd. Apparently some of them had been hatched for several days because they were quite numerous and some were partly grown. The larvae feed upon the ovary of the blossom and in many cases they will be found with the head and part of the body within the ovary. Usually only one larvae is found in a blossom but occasionally two. In a few cases larvae were found feeding within the seed capsule but these were comparatively rare. On August 6th the larvae were very numerous and in all stages of growth from recently hatched to full grown. The first pupa was found on August 7th. They are buried about two inches in the soil and are very active and wriggle around when disturbed. Both larvae and pupae were present all through August and until September 21st when the last observation was made. During September adults, presumably, of the new generation were very numerous in the blossoms.

ADULT: Form oval, strongly convex and sparsely clothed with brownish hairs. Color black and partly shining above; legs and antennae rufous; first segment of antenna darker than remainder; posterior legs usually somewhat darker than the others. Dorsal surface of body deeply and thickly punctate; punctures on head and dorsal surface of abdominal segments somewhat finer. Posterior half of sides of

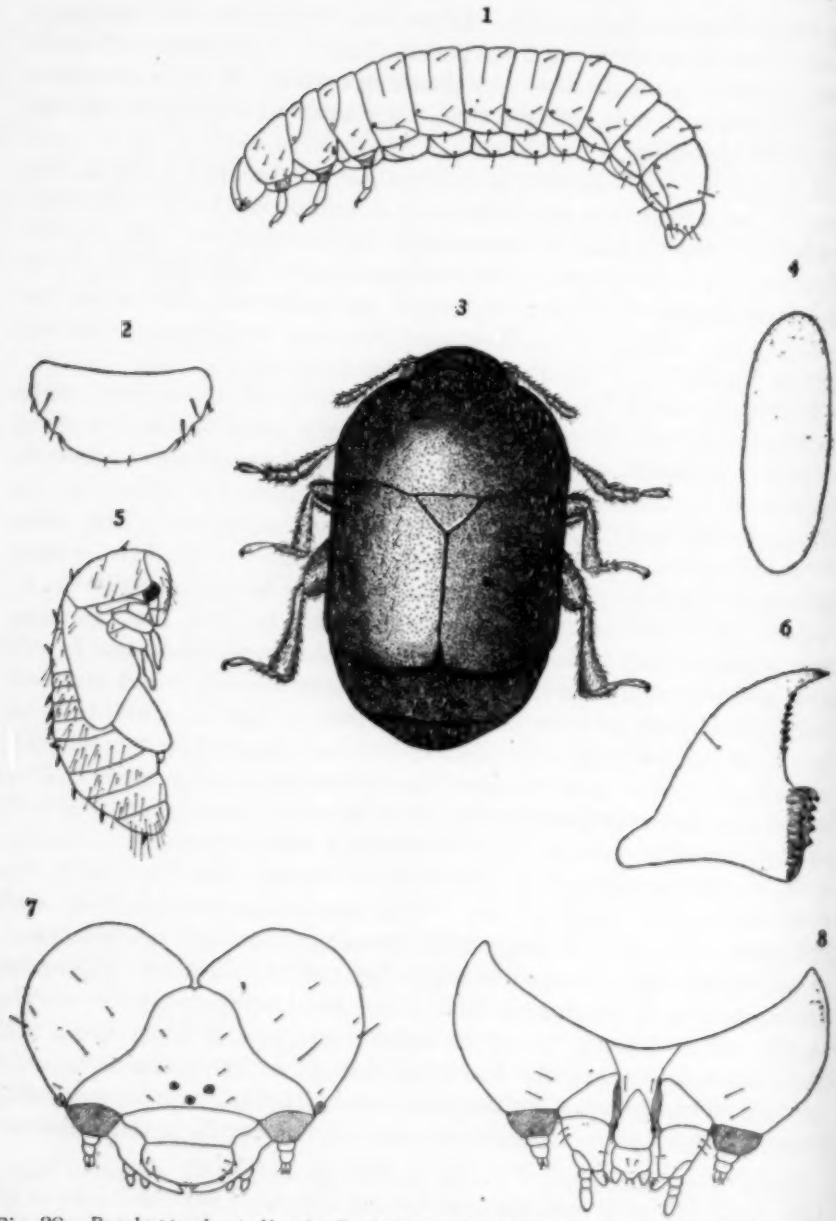


Fig. 38. *Brachypterolus pulicarius* L. 1. Larva, 2. Labrum of larva, 3. Adult, 4. Egg, 5. Pupa, 6. Mandible of larva, 7. Dorsal aspect of head of larva, 8. Ventral aspect of head of larva.

scutellum smooth shining and impunctate. Head about half as wide as thorax. Antenna sub-capitate; club elongate; joints one and two subequal, globular; three elongate and subequal to four and five. Thorax convex, about two-thirds wider than long; sides parallel at base, strongly arcuate towards apex; apex strongly emarginate, angles acute; posterior angles rectangular; base trisinuate. Elytra one-third longer than thorax; apices rounded and separated. Two abdominal segments exposed dorsally, female; three, male. Abdominal segments two and three, ventrally, very short, not equal to fourth; fourth longest. Middle and posterior legs flattened; tibiae dilated at tip and crowned with a row of equal spines; outer margin of tibiae of anterior and middle legs with a row of spinules. Length 2.2–2.6 mm. Width 1.0–1.2 mm.

EGGS: The egg is about three fifths of a mm. long. Color white when first laid but yellow just before hatching.

LARVAE: The full grown larva is about 5.5 mm. long, strongly convex above and flattened below. Mandibles, head, and thorax brownish with light median stripe on prothorax; remainder of body pale yellow. Ten abdominal segments; tenth much reduced. Head heart-shaped, somewhat broader than long. Epicranial sutures distinct and extending from median line of caudal margin of head to antennal ring in front of simple eyes. Frons sub-triangular and bearing three depressions in the form of a triangle near the cephalic margin; also provided with three pairs of setae. Frons and clypeus not distinctly divided. Labrum about twice as wide as long; anterior margin somewhat crenate and rounded; margin provided with four small setae on each side; two other more prominent setae placed back from the margin. Epicrania large and rounded posteriorly; each lateral half bears eight setae, six dorsally and two ventrally. Simple eyes represented by two small lens-shaped spots situated behind the base of the antenna; some specimens show a trace of another pair of simple eyes situated caudad of the first pair. Antenna with three segments; basal membrane large and does not show any evidence of chitinization; first segment much broader than long, second about as broad as long, third consists of two parts, one lying above the other; dorsal piece of terminal segment rounded at tip and bears a small seta and tubercle, ventral piece slightly longer and conical. Mandible dark brown and sickle shaped; pointed apically and provided with eight acute teeth near apex; molar part bears two rows of five teeth each; first pair large and directed backward, others decrease in size posteriorly. Maxilla consists of cardo, stipes, palpifer, palpus and mala. Cardo somewhat membranous, large and triangular. Stipes chitinized and provided with three setae, two on outer margin and one on the inner. Palpus three-segmented, first two segments about equaling the third in length. Mala provided with three setae on inner margin. Labium consists of submentum, mentum, ligula and palpus. Submentum membranous and not distinctly separated from gula. Mentum chitinized and provided with two small setae. Ligula small and not separated from mentum; provided with two setae at tip. Palpus one-segmented and projecting forward slightly further than ligula. Prothorax undivided dorsally; provided with five setae on each side. Meso and metathoracic segments divided dorsally into prescutum, scuto-scutellum and pre-epipleurum; alar area not marked; they are provided with setae as follows: one on prescutum, one on scuto-scutellum and one on alar area. Each typical abdominal segment divided into prescutum, scuto-scutellum, epipleurum and hypopleurum; provided with setae as follows: one on scuto-scutellum, one on alar area, one on eqipleurum and one on hypopleurum.

Spiracles are present on the mesothoracic segment and on the first eight abdominal segments.

PUPA: The pupa is about 2.8 mm. long and 2.0 mm. wide. Color yellow. Body rather sparsely covered with long brownish hairs, expecially head and last abdominal segment. Legs and wing pads closely appressed to the body. Tarsi distinct but do not show segmentation. Head drawn into thorax to eyes; mouthparts pressed close to body; labrum and mandibles distinct, latter chitinized. Antenna club-shaped but not segmented. The dorsal surface of thoracic segments provided with four pairs of spines which project towards head. Each abdominal segment provided with a pair of spines which project caudad.

A STUDY OF THE BIOLOGY OF THE PARSLEY STALK-WEEVIL *LISTRONOTUS LATIUSCULUS* BOHEMAN COLEOPTERA: CURCULIONIDAE

By ALFRED M. BOYCE, *Cornell University*

ABSTRACT

An infestation of the Parsley stalk weevil, *Listronotus latiusculus*, exists in the progressive market garden section of Long Island near New York City and appears to be a serious menace to carrot growing there. The results of one season's study (1926) are reported, including observations on life history and habits, food plants, distribution and a note on possible control.

For the past few years the market gardeners in the vicinity of Valley Stream, Long Island have experienced losses due to the depredations of a comparatively new pest of the carrot crop, namely *Listronotus latiusculus*. The writer had the opportunity to make a study of this pest during the growing season of 1926.

HISTORICAL

L. latiusculus was first described from Pennsylvania by Boheman in 1842. The species was taken originally from the Arrow weed plant, *Sagittaria variabilis* and received the common name of the Sagittaria curculio. In 1902 when the fact was established that this species had migrated to the parsley plant as a host and that most of its eggs were deposited in the stalks, the name of parsley stalk weevil was appropriately given to it. More recently when it was known to attack carrots it has been referred to in literature as the carrot weevil.

Blatchley and Leng in describing the Genus Listronotus, reported that all the species whose habits are known breed in semi-aquatic plants. Since *Sagittaria variabilis*, the original host of *latiusculus*, grows in a semi-aquatic environment, we must naturally assume that this species has changed its habitat to dry land plants. Furthermore, as will be

pointed out later, it has apparently changed its oviposition habits with its change of host.

In this study adults reared from larvae taken from roots of the present known host plants were identified by Dr. E. A. Chapin of the U. S. Bureau of Entomology and by Dr. Charles Schaffer of the Brooklyn Museum as *L. latiusculus*.

Distribution

According to Blatchley and Leng the general distribution of the weevil is as follows, "The type, is from Penn. Ranges from Quebec, New England and Michigan, west and south to Colorado, Kansas and Georgia."

The first record of its economic importance was in 1902 when it was reported as causing serious injury to parsley grown at Four Mile Run, Va. The growers there had first noticed its presence in 1900. In 1915 it was reported for the first time from Connecticut, causing injury to parsley growing in cold frames near New Haven. In 1916 parsley grown in the experimental garden attached to the Department of Agriculture at Washington, D. C., was noted to be injured by this species. In 1922 it was reported as injuring carrots in a backyard garden at Washington, D. C., and in 1923 as being a serious pest of carrots in the vicinity of Valley Stream and Astoria, L. I., N. Y., and in a portion of southwestern Illinois.

Food Plants

In this study adults were reared from larvae taken from the roots of carrot, wild carrot (*Daucus carota* L.), curled-leaved parsley, hymicha (Hamburg parsley, *Apium petroselinum* L.), and dill (*Anethum graveolens* L.), all of these being members of the Umbelliferae family. An attempt was made to determine which of these host plants was preferred by the insect but no conclusions could be drawn as there was a lack of evidence to show a distinct liking of one host over another. On inspecting wild carrot plants growing naturally along roadsides, in vacant lots and elsewhere it was found that the larger percentage of them were infested with larvae of what proved to be, when reared, *L. latiusculus*. Such a condition was found to be general on Long Island, wherever the wild carrot grows naturally. This fact may be of great importance in certain situations for such a condition might well afford a potential source of infestation.

Injury and Losses

On Long Island it is the early crop of carrots that is attacked and losses involving as much as 75% of the crop are reported by growers.

This injury in some cases has been great enough to discourage the growing of the early crop. The later crop is practically free from injury.

The greatest damage is done by the larvae. Their feeding in the roots results in injury which affects the sale of the carrots. In the case of parlsey (curley-leaved variety) the stalks and leaves are the salable parts and injury to the roots of this plant when severe, result in the yellowish sickly condition of the leaves, which renders them unsalable. With hymicha the major injury is to the roots which greatly reduces their market value. With all the hosts of this species some stunting was noted, the degree of which depends primarily upon the size of the plant when the larvae begin feeding in the roots and the number of larvae present.

Description

THE EGG. The eggs are ovoid and somewhat elongated, measuring about .75 mm. in length by about .50 mm. in width. They are light colored when first deposited but soon acquire a dirty brownish or dusky color.

THE LARVA. The larva when full grown measures from 6 to 8 mm. in length and is only slightly curved in form. It is a legless grub, creamy white in color except for the head which is amber colored or reddish brown, the mouthparts being much darker. Each segment of the body bears a series of setae, while the first three anterior ventral lobes have a group of setae on each. There are a few scattered setae on the head.

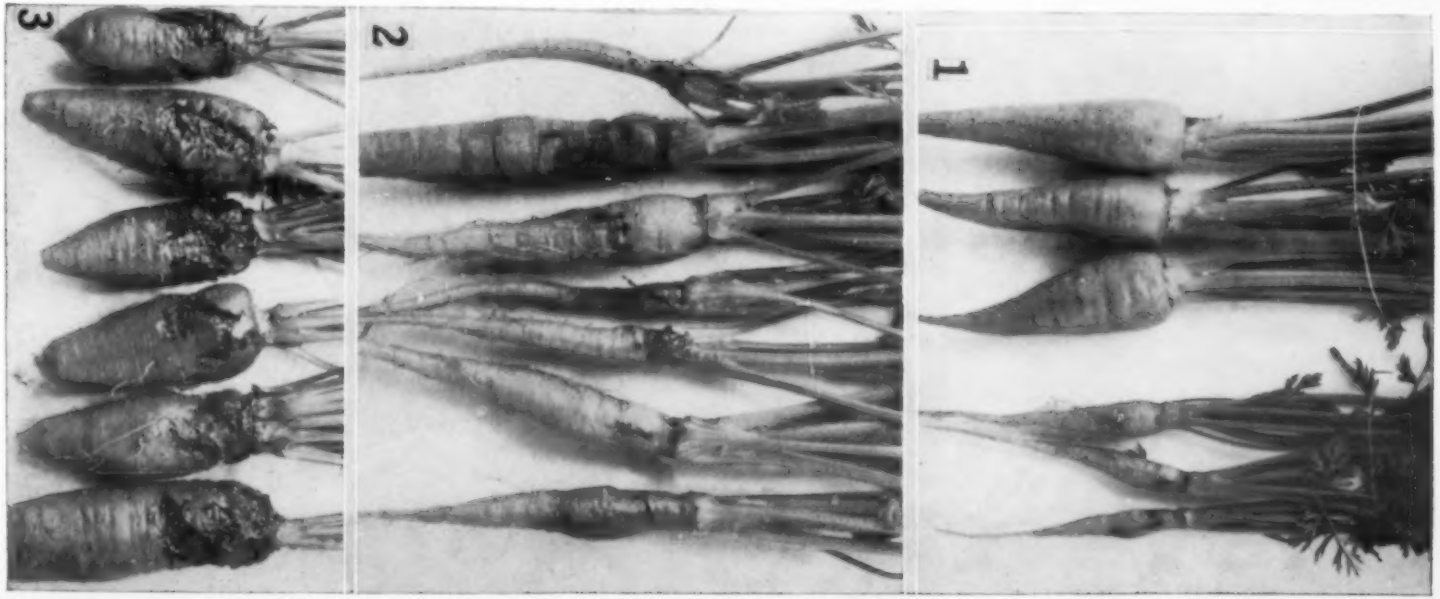
THE PUPA. The pupa is of the exarate type, measuring from 6 to 7 mm. in length, and is creamy white in color. It is well provided with stiff brownish spines, there being a transverse row on each abdominal segment, the head, thorax and femora of the legs bearing them in definite positions also.

THE ADULT. The adults are from 5 to 6 mm. in length, the males being decidedly smaller than the females. The ground color of the body is very dark, nearly black, and the thorax and elytra are heavily armored with dull grayish and cupreous tinged scales, those on the thorax being slightly larger than those on the elytra. The grayish scales form three faint stripes on the thorax and a slight mottling on the sides of the elytra. Each stria of the elytra bears a row of short grayish setae and the venter of the thorax and abdomen is clothed with numerous short setae. The head has scattered scales and more short cupreous setae with rather a definite arrangement. The beak is slender with three feeble carinae dorsally. The antennae and tarsi are deep amber colored or reddish brown, and the femora and tibiae of the legs have scattered scales and numerous short setae.

Life History and Habits

Three generations were reared on Long Island, with considerable overlapping of the broods. There was apparently continuous breeding thruout the season.

THE EGGS. The first deposition of eggs was noted on May 21, when the carrot plants were about three inches high. They are deposited in



Parsley stalk weevil—1. Infested and uninfested carrots of the same age from the same bed. 2. Young carrots infested. 3. Injured carrots at harvest.

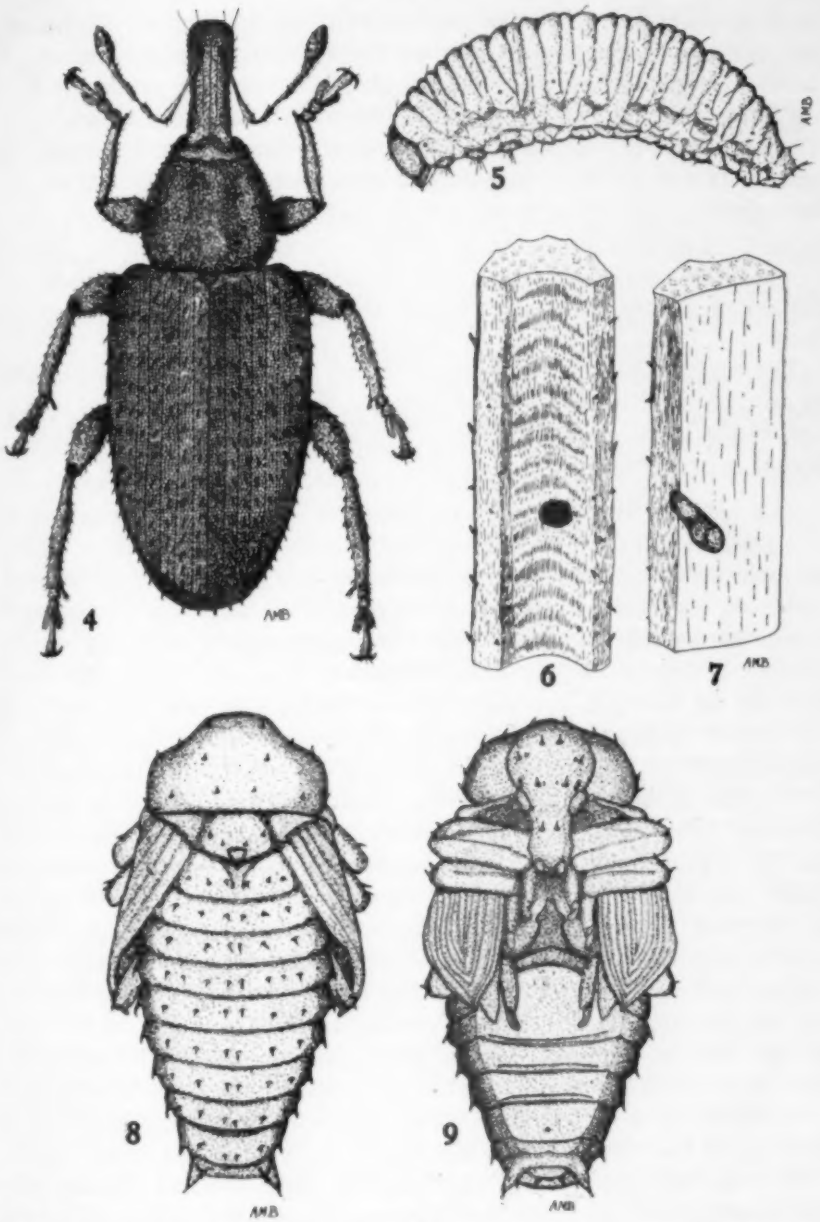


FIG. 39.—Parsley stalk weevil.—4. adult. 5. Full grown larva. 6. Egg-cavity in carrot leaf stock. 7. Section of same. 8. Pupa, dorsal view. 9. Pupa, ventral view.

cavities which are hollowed out in the stalks by the female. There are usually three or four eggs in each cavity with occasionally more, some cavities having as high as seven or eight. The cavities are sealed immediately after the eggs are placed in them, with a black exudate from the caudal end of the body, probably a secretion from the alimentary canal. As many as eight egg-pockets were found on a single plant and from counts made of the position of the cavities it was shown that fully 80% of the pockets are on the inside or concave face of the stalk. Early in the season, before cultivation of the crop was begun, the crowns of the young plants were exposed and the females freely oviposited in them.

The eggs of the first generation hatched in from 10 to 14 days with an average length of about 12 days for the incubation period. The eggs of the later generations hatched in from 7 to 10 days, the average period being about 8 days.

THE LARVA. The young larva on emerging from the egg is very active and begins feeding on the interior of the stalk, making a tunnel which in most cases extends downward toward the base. When the egg-cavity is made within one or two inches above the base of the stalk the larvae usually tunnel downward and enter the carrot at one side of the crown. But when the larva is hatched in an egg-cavity relatively high up on the stalk it usually tunnels for an inch or two upward or downward, makes an exit hole and either crawls down the outside of the stem or drops to the ground to enter the carrot from the soil.

The first indication of the presence of a larva in the carrot is its tiny entrance hole, which is rusty in color. It was not uncommon to find carrots containing larvae which entered the root as deep as one inch below the surface of the soil. In some instances nearly full grown larvae were found in the heart of the bases of the stalks, having not yet entered the root, tho having chewed off the bases of most of the stems. When the larvae have entered the carrot they tunnel in a more or less zig-zag direction, confining their feeding to the upper half of the root and in the outer fourth, seldom attacking the heart. The epidermis over the tunnels becomes dark brown and dies exposing the bare tunnels with their damp sticky frass. There are usually several larvae in a carrot and their tunnels may run together resulting in a broad lesion.

The larval stage lasts about fourteen days. When mature, the larva ceases feeding, leaves the carrot and enters the soil to a distance as far as two inches from its exit, where it constructs an earthen cell and pupates. In constructing this cell it bends its body back and forth

very rapidly thereby pushing the soil from around it and firmly packing it at the same time. This usually requires about 10 to 12 hours, and then the larva quiets down and transforms to a pupa within 1 to 5 days. This appears to be a definite prepupal stage and varies considerably in length with the different individuals. In rearing cages the first larvae to pupate did so on June 30th.

THE PUPA. The pupae remain inactive in their earthen cells thruout the pupal period unless disturbed. If the cell is destroyed they attempt to build another by wriggling their abdomen back and forth, a characteristic habit of the larvae. Records show that the pupal period lasts from 6 to 12 days, with an average of about eight days.

THE ADULT. The first adult emerged in the rearing cages on July 8. After transformation to the adult stage the weevils remain in the pupal cell for one or two days and then migrate to the surface of the soil. They are of chestnut brownish color at this time and are easily recognized as having recently emerged from the soil.

The adults that deposited the eggs for the first generation were first observed on May 21, presumably having then recently emerged from hibernation. Copulation takes place in the spring before the eggs are laid. The males were observed to remain clinging to the females for a period of several days. The beetles feign death when disturbed and remain motionless for a short while thereafter. They feed by shaving off the epidermis of the stalk with their mandibles or they may chew in the tissue in one spot until a cavity is formed. This practice is most characteristic during oviposition and into such cavities the eggs are placed and the opening sealed with a blackish material. It is interesting to compare these egg-laying habits with those described for this species by Dr. C. M. Weed from Ohio in 1889. Dr. Weed says, "*L. latiusculus* breeds in the stalks and seed heads of the broad leaved arrowhead, *S. latifolia* Willd., the eggs being laid in bunches of five to ten on the leaf stalk, and covered with bits of epidermis chewed up by the mother beetle."

The beetles have never been observed in flight altho they have fully developed wings. An examination of their wings furnishes some evidence that they do not fly except under the most favorable conditions, as the wings appear to be inadequate to efficiently support in flight a body of such size. A study of the infestations also indicates that they do not fly actively, since they were found only in carrots planted on soil that was infested the previous year.

How and where the insect hibernates has not yet been definitely established but there are indications that it passes the winter in the adult stage in the area where its food plant was grown that season. Some evidence to support this is derived from the fact that adults were taken early in the winter from debris about one inch below the surface of the soil in a field on which infested carrots had been grown. The common practice among the truck growers is to apply a heavy application of manure on the soil after the last crop is harvested and then turn this under to a depth of five or seven inches. In the spring plowing and harrowing much of the soil that was turned under in the fall is again brought to the surface. Such a practice may furnish excellent conditions for the hibernation of the weevils.

Seasonal History

First generation larvae began to hatch out on June 2, and the first adults appeared on June 25. The peak of emergence of this generation was estimated to have been about July 22.

Females of the first generation began to oviposition July 17 and adults began to emerge on August 16, the peak being reached about September 15.

For the third generation oviposition began on September 6 and the first adults appeared October 9.

The injury is caused by larvae of the first and second generations and it is very likely that a full second and a third generation do not develop under existing conditions, since practically all the early crop of carrots is harvested by August 15 at the latest. In no instance have the beetles been observed to feed on or breed in any of the vegetable crops following carrots. If the weevils are capable of flight it seems reasonable to assume that they would migrate to nearby or adjoining plots of the late crop of carrots. Such a migration was not observed.

Methods of Control

Rotation of the carrot crop appears to be entirely effective in controlling this pest. However, in rotation, other members of the Umbelliferae family should not be used as the weevil has been found to attack them. The effectiveness of rotation in elminating this pest has been fairly well demonstrated in several cases. A typical one being the case of a grower who planted his main carrot crop on a plot just across a roadway from an area that was heavily infested in previous years. He also planted one bed in the previously infested area to carrots again

and in this bed there developed a 70% infestation, while in his main crop no infestation was in evidence.

Some experiments were made on a small scale with arsenate of lead spray, sodium fluosilicate dust and carbon bisulphide emulsion but the data obtained was of little value.

It is possible that late thinning would be effective to some degree in that many plants containing egg-cavities and the earlier of the first generation larvae would be pulled up and these stages would not have a chance to develop.

QUANTITATIVE METHODS OF COLLECTING AND REARING SOIL CUTWORMS[1]

By KENNETH M. KING and N. J. ATKINSON, *Saskatoon, Saskatchewan*

ABSTRACT

In this paper are described in considerable detail the methods of collecting and rearing soil-infesting cutworms which several years experience has shown to be the most suitable and efficient, under Saskatchewan conditions, for securing accurate estimates of the relative (and to some extent the actual) abundance of the cutworm species involved, and the abundance and effectiveness of their various insect parasites and diseases. An attempt is made to distinguish between those methods which are essential under nearly all circumstances, and those which, though non-essential, should be employed when conditions permit. A few instances are cited illustrating the working out of these methods in actual practice.

Three general conclusions are drawn. 1. Each cutworm must be kept isolated from the moment of collection and be reared with such precautions as will minimize the subsequent effects of the changes or conditions or the possibilities of cross-infection. The employment of this technique, more than any other point in the procedure, conditions the entire results. 2. The methods of collecting must be so systematized as to make each collection truly representative of its immediate location. 3. More valuable returns are secured, for the efforts expended, by making several successive or otherwise comparative small collections rather than a few large ones.

The place which the collecting and rearing of immature stages holds in connection with insect field work is well recognized. In studies of economic soil-infesting cutworms the rearing of larvae collected from natural conditions is usually the only satisfactory method of estimating the relative abundance and effectiveness of the various insect parasites and protozoan, bacterial or fungous diseases occurring. It is frequently also the only accurate means of determining the various host species concerned and their proportional numbers.

Several years experience in this work have convinced the writers that, in Saskatchewan at least, dependable or comparable results in the

[1]Contribution from the Division of Field Crop and Garden Insects, Entomological Branch. Dept. of Agric. Ottawa.

above respects can seldom be attained except by systematized methods of collecting and by careful individual rearing of larvae.[2]

The data obtained in any such work should, of course, reflect as accurately as possible, considering time and labour limitations, the conditions as they existed in the area under study. The writers find that, even in relatively superficial observations, the employment of the methods outlined below gives greater efficiency of labour than does the somewhat haphazard collecting and massed rearing of larvae often used. The methods described in this discussion are those which have proved most effective under Saskatchewan conditions. The principles brought out, however, appear to be equally applicable not only to other regions but also to groups of insects other than soil cutworms.

Selection of "Fields" for Collections

Throughout the present paper, the word field is used in a somewhat restricted sense as the most appropriate term to designate an area, varying in size from ¼ acre to 100 acres or more, but relatively uniform with respect to the more important conditions affecting cutworm distribution and abundance. Thus the limits of the field, in the sense used here, usually coincide with the boundaries of the enclosed area (or field in the usual sense), but may not always do so. The keyword is "relatively" uniform,—that is, the decision in any instance must be based on the judgment and experience of the observer.

The factors which have proved worthy of consideration, as affecting the rate of infestation and the cutworm species involved, include the topography, the soil and its state of cultivation, the vegetation, and the known or probable proximity of moth food at the time of major flight of the various species during the preceding year. The potential importance of these factors is well illustrated by the pale western cutworm,[3] the abundance of which in different fields in a district in which it is endemic in a given year has been found to bear a very close relation to the amount of surface disturbance during the preceding August and early September. The type of soil, as contrasted with its surface condition resulting from cultivation, has been found by the writers in a few instances to be the critical factor, influencing not only the relative

[2]The investigations since 1922 have pertained primarily to the red-backed cutworm (*Euxoa ochrogaster* Gn.) but have also dealt with nearly all of the cutworms of economic importance in Saskatchewan. Previous experience with other noctuid species in two widely diverse environments further confirms these conclusions.

[3]Seamans, H. L.; The Pale Western Cutworm: Canada Dept. of Agric. Pamphlet No. 71, n.s., 1926, p. 3 and 6.

abundance but also the proportions by species in different parts of the same enclosed area of otherwise apparently uniform conditions. Similar significant differences between the cutworm populations of knolls and hollows, apparently induced by differences of drainage and insolation in their direct and indirect effects, have been found even where the soil type seemed the same. Relatively minor fluctuations of cutworm population recurring at small space intervals in a field are commonly encountered and may be discounted. On the other hand, any marked variations either in abundance or in proportion by species in different parts of an area should be considered significant even when no explantion can be offered for them.

A single collection, obtained and reared in the way described below, gives, if an adequate number of larvae is taken, a relatively accurate picture of the conditions as they existed in the field in question on the date of collection. This work may then be extended by means of similar collections in the same and other locations with three ends in view:—1. To follow the development of parasitism and disease with the advance of the season, in order to estimate the cumulative mortality. 2. To compare the results with those of other collections from the locality or district, to show the influence of environmental conditions. 3. To assist in the interpretation of less extensive data secured in other portions of the region involved.

The first of these aims is best accomplished by making successive collections of larvae in the same or "standard" field throughout the cutworm season. The results obtained afford excellent data on the development of disease and of infestation by parasites. These collections are started as soon as it is possible to find the young larvae, and are continued at intervals of a week or ten days, throughout the season of the species under study. Otherwise such parasites or diseases as attack either the early or the late larvae alone will be overlooked and the true cumulative mortality will not be obtained. In following this plan it is essential to choose a "field" sufficiently large and heavily infested that the successive collections will not seriously decimate the cutworm population. Otherwise the true natural balance is upset, probably increasing the rate of parasitism and decreasing the mortality due to disease. Whenever possible, as in years of heavy outbreaks, it is advisable to select for the "standard" a field representative of the outstanding crop of the area, in Saskatchewan a field of wheat or other grain, thus making the results more readily comparable from year to year.

If time and the availability of heavy infestations permit, valuable results are secured by selecting for successive collections several fields differing somewhat in environmental factors. Single collections may also be taken in many fields representing a wide variety of conditions, for comparison with each other and with the "standard" collections of the same date. In this, the experimental ideal of variation of but a single factor at a time should be kept in mind. This work should be carried on in the same immediate district so that the results may not be obscured by the effects of critical differences in meteorological factors.

It is frequently desired, in connection with a widespread outbreak of a destructive species, to gain some idea of the conditions throughout a large region. The data gained by intensive quantitative work in one district assume great value when attempting to interpret the results from scattered single collections, especially if studied in conjunction with a careful comparison of the current meteorological conditions in the several areas. Such scattered single collections are most significant when it is possible to take them as the cutworms are nearing maturity.

Methods of Making a Single Collection

In order to make a collection representative, the cutworms should be taken from a number of different locations or plots in the "field" under study. The size of the plot to be examined at each location may be determined either by the method of unit number or by that of unit area. In the first instance, the search is continued in each location until the selected number of cutworms, usually five or ten, has been secured. In using the second method, the size of the unit area is first selected after preliminary examination with reference to the rate of infestation, and then is kept uniform throughout the field; a plot of one or two square feet is usually convenient. The method of unit area[4] requires little more time, and permits quantitative data to be secured not only with respect to the density of the cutworm population, which is of great importance in relation to the spread of disease, but accurately reflects its composition as to species, and the number of injured and uninjured plants of the different kinds. In this way definite information can also be obtained with respect to predators, the prevalence of which can only be estimated by field observations.

If sufficient locations are taken they may well be determined by chance by taking them at definite intervals, or it may be preferable to

[4]An instance of the results obtained in a specific instance by use of this method is given by King and Atkinson, Scientific Agriculture, VII, Nov. 1926. p. 87.

select several locations which appear representative of the whole area as to important environmental factors. We have found that a combination of the two is usually of advantage, selecting each plot to be typical of its general location as determined by systematic sampling of the whole field. The plots in seeded fields must be chosen to include proportional parts of row and interspace.

Notes should be taken at the time of collecting, not only on the general field conditions already referred to but also on the individual plots, because of the effect of various environmental influences or natural control factors. Notes on the vegetation of the areas from which the larvae are taken, including under this heading both the crop and weeds and their stages of development, are important in relation to the percentage of parasitism, particularly by tachinids, such as *Gonia* spp., which oviposit on foliage. The actual significance in each case can only be determined by local observations on the habits of the flies concerned. The condition of the soil as regards moisture, temperature and looseness may influence parasitism and disease directly as well as indirectly through its effect on the relative stage of development of the host larvae.

Representative plots having been selected, the soil in each should be subjected to a careful examination in order to secure all the cutworms present. The tendency, particularly if the soil is wet, is to overlook the smaller larvae and those at some depth, with the result that the conditions existing at the time of collecting are not truly reflected.

The most essential point in manipulation is that each larva must be kept isolated from all others from the moment of collection until maturity. When near to headquarters each larva is put into a one or two ounce salve tin without either soil or food. When on a field trip of several days duration each larva is put into an individual tin, as before, but with a small amount of fairly dry soil and of some suitable food plant. The larvae can then be left for three or four days without attention. Record numbers or such other data as are necessary are written on each tin and the larvae are brought back to the laboratory for attention and rearing.

Records of the approximate stages of development of the larvæ are of value and may be made either in the field or during the preliminary sorting in the laboratory. With experience very accurate estimates can be quickly made for a species which has been studied in all instars.

Size of Collection

The size of collection required in any instance is determined in great measure by the accuracy of the method of collecting and rearing and by the number of collections taken, as well as by the time available. As in other quantitative work, the chief value of any collection or "sample" of cutworms lies in its comparison with other similar samples.[5] In an investigation of this kind, this involves a compromise between the completeness of each sample and the securing of sufficient similar samples, in order to obtain the fullest comparative value with a minimum expenditure of effort. We have found that, when the careful technique recommended is employed, fifty larvae of a single species in each collection is a sufficient number to show with considerable accuracy the total rates of mortality from disease and from combined parasitism. The data from a single collection of this size are usually of little significance in relation to the percentage of parasitism by any one species, but a relatively accurate estimate of the prevalence of the various parasite species is made available by a careful interpretation and averaging of the results from the successive collections in the same field or from those in different fields of the same district. Occasionally it is advisable to secure one hundred cutworms, but usually greater efficiency of effort is secured by taking instead two collections of fifty larvae each, either on different dates or in different fields.

Although slight reference has been made here and there to different cutworm species, for purposes of the discussion above an unmixed infestation has been assumed. The conditions found in actual practice may be divided roughly as follows:—1. One or more major species, with or without one to several minor species of distinct though slight economic importance, all the species being readily and accurately distinguishable as larvae by experienced observers. 2. Occurrence of a group of species, the larvae being so closely related in appearance, habits, and stage of development, as to be separable only partially if at all, although this group as a whole is distinguishable from other major and minor species. Under the former circumstances the proportion of the various species is determined by the quantitative methods of search. The first fifty larvae taken of each major species are reared as a collection from the field in question; the occasional cutworms met with of a minor species are reared as a sub-group with other similar sub-groups secured in other fields, to give a general idea of the status of natural control of the species, or are sometimes discarded if the same

[5]Vide Allen, W. E.; The Investigation of Ocean Pasturage; in Ecology 2, p. 218.

species is a major one in other nearby fields. Where an important but confused group, made up of several species in varying proportions, is encountered, a collection is made of a hundred or more larvae of the group; this is reared as a unit but is subdivided as far as possible, especially when greater maturity of the larvae renders identification easier.

Methods of Rearing

The larvae are reared in the laboratory in the tins in which they are placed in the field. All soil cutworms are reared with a moderate amount of soil in the cans. The most desirable soil is a sifted sandy loam which will not form into lumps. The soil is brought into the laboratory some time in advance and allowed to dry out, which lessens the probability of introduction of disease. Small quantities are moistened as required for use. The tins are filled half full of this soil; when larvae have been brought in with soil this is replaced by the laboratory soil.

White Dutch clover is used as food for most of our cutworms. Its advantages are that it is easily obtainable locally from the lawns, is readily eaten by most larvae, keeps fresh for several days and, especially if cut when dry, gives no indication of favouring disease. We possess, also, good evidence that parasites are seldom, if ever, introduced by the use of this food. The ideal, we admit, is that the food should be grown in a greenhouse but, when working with many larvae, this is impractical.

The soil is kept near the optimum moisture content which, it should be noted, varies for different species and can only be determined by experiment or observation. While perhaps the optimum temperature conditions for each species would be more desirable, our laboratory temperatures, ranging from 60 degrees F. to 75 degrees F. prove very satisfactory. The trays containing the tins are all kept together to obtain uniformity in this latter respect.

Treated in this way, the larvae require attention only every third or fourth day and may, if it is necessary, be left for five or six days without suffering serious harm. Ordinarily the soil is not changed at all but the main debris is removed before adding fresh food. Where there is evidence of disease among the larvae two or more pairs of forceps are used for handling them and are constantly sterilized in alcohol or some other disinfectant. Care must be taken not to assume that larvae from which no parasites seem to have emerged in the soil have died from disease, since some of these parasites, particularly those of the younger cutworms, may very easily be overlooked.

As a guide to when moths are likely to emerge it is handy to write the date of pupation on each tin though the darkening of lightly chitinized pupae also serves as a very good guide. Excellent moth emergence is secured by putting out the tins containing nearly mature pupae under gauze-covered lamp chimneys or inverted glass sealers. When working with a large number of pupae economy of labour may be effected by putting out the nearly mature pupae in the ordinary deep one-ounce salve boxes (¾ inch high) in which they have been reared and covering them with sheets of glass. A little soil is left in the cans and moistened occasionally. As the moths emerge the determinations are checked before removing the glass. If the glass is kept covered with dark paper except at the time of examination very few moths are lost at the time of removal.

Dissection of larvae taken in the field is frequently a valuable supplement to rearing. It is seldom a satisfactory substitute, however, because it does not permit the recognition of the early stages of disease, nor afford evidence on the outcome of superparasitism (*s. lat.*) involving either two insect parasites or a combination of insect parasitism and disease.

Instances of Practical Application

Though the methods outlined above sound rather elaborate in description they are not complicated in their application. Moreover, from the standpoint of entomological technique they are entirely desirable if not always essential, for otherwise there is always the possibility of artificial infection by disease, of the introduction of parasites, or of cannibalism. They are the only methods we have devised for *Euxoa ochrogaster* which can be relied upon to furnish significant results.

Larvae of *E. ochrogaster* are very susceptible to several diseases and, when warm wet weather occurs and larvae are abundant, epidemics may develop which spread with great rapidity. While the manner of infection is not established, it is undoubtedly favoured by the massing together of many larvae. In 1923, a year with a rather wet May and a very warm wet June, we failed to rear moths or parasites from any of forty larvae collected at Rosthern, fifty miles north of Saskatoon, on June 26th. These larvae were placed several in a can until they were brought back to Saskatoon a day or two later, and the mortality was undoubtedly very much higher than that occurring in the field.

The results of 1923 contrast strongly with those of 1925, a year in which disease was far more prevalent in the field but in which the

recommended technique had been fully adopted. The percentages of larvae dying from disease and succumbing to parasites in four successive collections, the last three of which were made from a "standard" field, the first from a very similar nearby field, all treated in the standard manner described above, is shown in Table 1.

TABLE 1.—MORTALITY OF LARVAE OF *E. ochrogaster* FROM FOUR COMPARABLE COLLECTIONS IN 1925

Date of Collection	Mortality from Disease	Mortality from Parasitism	Moth Emergence
May 15th	17%	21%	62%
May 26th	30	17	53
June 9th	54	22	24
June 25th	66	32	2

The results obtained in 1925 demonstrate, when compared with the lack of results in 1923, the effectiveness of the technique. They further illustrate well the valuable results which may accrue from successive periodic collections in the same field. The rate of parasitism throughout the season is truly reflected, this condition being confirmed by other data. The slight decline in parasitism between the first two collections is attributable to the difference of locations. Even in this rather lightly infested field, averaging 1.8 cutworms to the square foot on June 9th., the final or cumulative mortality of *E. ochrogaster* was more than 98 per cent.

A collection made on May 20th, 1925 from a different field showed a larval mortality, exclusive of parasites, of only 6 per cent although the average length of larval life in the laboratory was thirty-seven days, considerably longer than that of the average collection. It is evident that, in spite of the unusually long period of rearing, there was no material mortality resulting either from the artificial conditions or cross-infection in the laboratory from other collections in which disease was prevalent.

One more striking instance in 1925 may be mentioned showing how well the collections represented conditions at the time of taking the larvae. On June 10th eighty cutworms were taken from a field where they were very plentiful. Of these 60 per cent died of disease, parasites emerged from 22.5 per cent and 17.5 per cent were reared to moths. From a comparison with the data from the "standard" location, Table 1, and considering the much higher rate of infestation, a more rapid spread of disease and a very high final mortality was anticipated. This was confirmed by a thorough examination of this field on June 27th when

not a single living cutworm or pupa could be found there, disease having wiped them out.

Mention was made earlier of the dangers of cannibalism. While *E. ochrogaster* does not exhibit this trait strongly, larvae of other species, such as *Porosagrotis orthogonia*, will injure one another and even slight injuries generally prove fatal. Two collections of larvae were made in 1926 at Indian Head. In the first the larvae were confined together with soil and food in a good sized tin for two days and then separated. The larval mortality of this collection, exclusive of parasitism, was 36 per cent. Another collection made from the same field six days later, the larvae all being kept separate, showed a larval mortality, exclusive of parasitism, of only 2 per cent.

ON A HIBERNATING CAGE FOR INSECTS

By H. PRELL, *Forstliche Hochschule, Tharandt (Saxony)*

In rearing different insects for scientific purposes sometimes difficulties are encountered which may be overcome by simple technical methods. While the rearing of insects during their feeding period is rather easy generally, heavy losses often occur during the long resting periods. These losses are especially serious during hibernation. Therefore in many investigations the care of hibernating insects needs special consideration.

When I studied the biology of some Diptera parasitic on European forest insects the method of handling puparia during hibernation assumed an exceedingly important role. *Phorocera agilis* R. D. (=*Parasetigena segregata* auct. nec Rond), a parasite of the nun moth (*Lymantria monacha* L.) and *Ernestia* (*Pauzeria*) *rudis* Fall., a parasite of the pine moth (*Panolis flammea* Goeze), are single brooded and pass almost three quarters of the year as puparia in the soil. During this resting period sometimes 90–100% of the puparia, which are hibernating artificially, are destroyed.

For lessening these losses, two methods of care seemed available. The first consisted of keeping the puparia under hibernating conditions as similar to those in nature as possible. The second consisted in trying to find methods which were adapted for hibernation, whether they had any resemblance to the natural conditions or not.

Generally the first scheme is followed. That is the reason why in Tharandt we started offering the hibernating puparia conditions superficially similar to the natural conditions by placing them in soil

or moss, in periodically moistening them when kept in closed rooms, or in burying them out of doors, etc. The results sometimes were satisfactory, but in most of the cases a considerable proportion of the puparia died either on account of drying out or through the development of moulds.

Not satisfied with these results, we decided to follow up the other scheme for hibernation, which disregarded the typical natural conditions and only gave attention to the physical advantages of certain natural conditions. In fact we thought it might be possible by simulating and accentuating the advantageous natural factors to obtain even better results than in nature.

In nature the hibernating pupae of different insects are not tightly packed in the soil, but they lie in cells; these cells are very conspicuous if they are represented by cocoons, made of silk or of faeces, but they are easily overlooked if their walls are not lined. If pupae or puparia which have been collected out of doors are placed in soil they really are not kept under natural conditions, since they are in close contact with soil on all sides. Packing in moss is better, because the contact is not so complete, yet even in this case the contact is more extensive than in a pupating cell.

This difference between real natural and so-called natural conditions seems to be of considerable importance. The tight contact between the buried puparia and the surrounding soil acts like a bridge for water and for many dangerous organisms such as bacteria, moulds, etc. While in nature the puparium within its cell after a heavy rainfall will be enclosed by a large air bubble saturated with water, in the artificial hibernating cage the water itself can reach the puparium. So when the hibernating cage is moistened the puparia very often will become quite wet and sometimes eventually drowned. At the same time the germs of disease wandering or growing in this water easily are able to attack the puparia. Finally in many hibernating cages the circulation of the air in the surrounding soil is lessened or even stopped by the moisture, thus developing detrimental conditions for the puparia and advantageous ones for the moulds. If on the contrary the soil in a hibernating cage is not moistened sufficiently, the puparia will dry out. Only a very careful moistening which requires much attention and very much time will lead to good results.

An apparatus which would avoid these difficulties should satisfy the following biological needs: (1) Procuring a permanently and equally moist atmosphere; (2) Avoiding every direct contact of the puparia,

etc., with fluid water; (3) Maintaining a permanent free air circulation. Further it should meet the following practical needs: (4) Reliable operation without much attendance; (5) Being easily cleaned and disinfected; (6) Moderate in price.

In 1913 I devised a hibernating cage to meet the preceding requirements.

The hibernating cage consists of four different separate parts, viz., a lower part, a screen false bottom (resting sieve), an upper part and a cover. The lower part (A) is a cylindrical watertight container which is to be filled partly with water. This container is covered by a wire

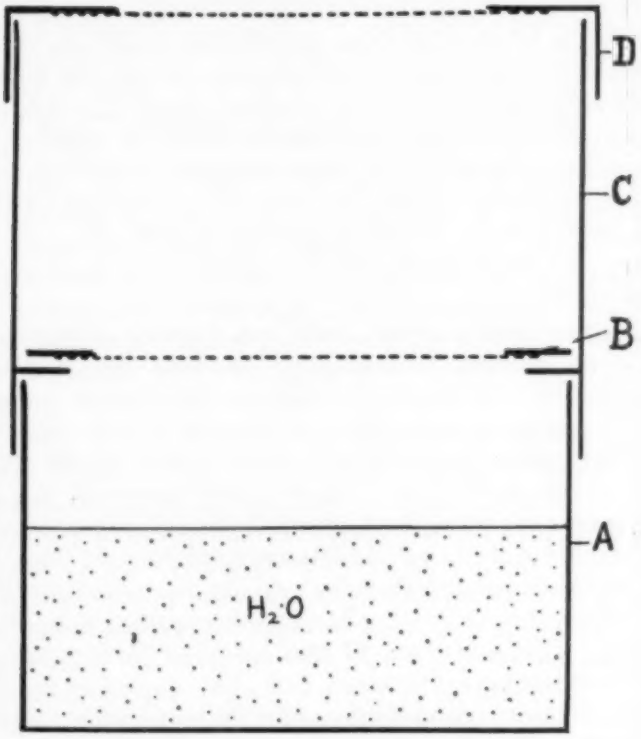


FIG. 40—Schematic diagram of hibernating cage.

screen false bottom in a zinc frame (B) on which the hibernating pupae, etc., are to be placed. This resting sieve at the same time forms the removable bottom piece of the upper part (C) resting on a ridge inside of the latter (upper part). The upper part is a cylindrical body which fits tightly on the container or lower part. It is closed by a detachable

cover (D) which is screened. The size of the whole apparatus can be adapted to any special requirements. Generally a cage of medium size having a diameter of about 5–6 inches is very convenient; smaller cages cannot contain so many pupae, while larger ones will be found not so handy.

As before mentioned, the pupae, etc., for hibernation are placed on the inner wire screen (B) without any surrounding soil or moss. One may add a very little moss in order to assist the emerging insects in shedding their pupal skins and in developing their wings, but it must be kept in mind that even sterilized moss is a good culture medium for the germs of diseases. If everything is properly prepared the hibernating cage operates automatically.

The water which is contained in the lower part continually evaporates and produces on its surface an atmosphere saturated with water. The walls of the lower and the upper part hold together this moist atmosphere so that there is only a small decrease of water content below the cover screen. Above the cover the decrease of the moisture will be very rapid and furthermore every slight motion of the air in a dry room will stop the evaporating moisture. So a continuous circulation of air is kept going on from the surface of the water around the pupae, etc., on the sieve up through the cover. The degree of this air current may be regulated by using covers with wire screens of different mesh; and furthermore it is possible by covering more or less of the upper screen to lower and finally to stop the air current. In this way the biological requirements seem to be fulfilled.

The moisture control by evaporation needs no continuous adjustment. It is only necessary from time to time to renew the water supply in the container, so the hibernating cage brings about a considerable reduction of work. If ever an infection by any disease occurs, it is quite easy to clean the whole apparatus. Every part can be separated from the others and disinfected by boiling, since the entire cage is made of metal. Finally, the price of this hibernating cage is very reasonable and if it is made of zinc with copper screen it will last for many years.[1]

So also the practical requirements seem to be fulfilled.

The results which we obtained in using the hibernating cage were fully satisfactory. The pupae of many different Lepidoptera and

[1]The cage may be cheaper still, if any commercial tins (cans) can be adapted to a similar combination, but in this case it will not last so long and is not so reliable. Another cheap but not so satisfying method consists in using a big glass jar with screen cover, in which is placed a smaller jar filled with water and carrying on its screen cover the hibernating pupae, etc.

Hymenoptera hibernated practically without any loss and even the puparia of Tachinidae gave about 100% emerging flies. After the first year's experience for hibernation we have placed all of the pupae and puparia in with hibernating cages which were kept in a dry room sheltered from the influence of frost.

Later we have tried to improve our method in two respects. The first improvement consists of the application of a short tube in the wall of the upper part on which a glass vial may be fixed as is used often in the rearing of parasitic insects in order to catch the emerging parasites. The second improvement consists of adapting the same hibernating cage for rearing a considerable number of different species which must be kept separate. For this purpose we use short glass tubes which on both ends are closed with gauze or mosquito bar and which are put vertically on the sieve.

Of course these hibernating cages cannot be used in the same way for all kinds of insects, since the amount of moisture required is often different, but for many of them at least hibernation is rendered quite easy. On the other hand, there is no question but that these hibernating cages also may be used as rearing cages for certain insects. By putting some soil on the sieve one is able to rear soil inhabiting larvae; by putting wood on the sieve it is possible to rear woodboring insects, which need a certain and permanent amount of moisture. Also in these cases the evaporating water automatically will maintain a more constant moisture than even the most careful spraying can produce.

No special mention is needed to show that the hibernating cage described is only the result of further development of methods already long in use by Lepidopterists for the hibernation of pupae. But upon visiting several entomological experiment stations, other investigators also complained of heavy losses of insects and especially of puparia of economically important Tachinidae occurring during their hibernation. For this reason it seems justifiable to describe the method by which at the Zoological Institute in Tharandt such losses were avoided to a large extent.

THE ENTOMOLOGICAL STATION AT TASHKENT, USBEKISTAN

By T. D. A. Cockerell

We arrived at Tashkent on Sept. 1, and left on Sept. 8, without having any opportunity to do much collecting. An excursion to the village Kujluk resulted in the capture of only a single species of bee, a *Tetralonia*. It was in fact the dry season, with conditions quite like those in late

summer in Southern California. The spring flora, as in California is rich and varied, with a great abundance and variety of bees and other insects. I was fortunately able to get a good idea of the Economic Entomology of Usbekistan (Russian Turkestan) through a visit to the admirable and well-equipped Entomological Station. This Station covers not only the field of Entomology, but also Phytopathology (I met N. G. Zaprometoff, specialist in diseases of cotton, grapes, etc.), and injurious vertebrates. I saw in cages the principal injurious mammals, one of the most important being a prairie-dog (*Cynomys fulvus oxianus* Thomas), very like our American species. Another important species is *Gerbillus eversmanni*. A species of *Ellobius*, burrowing in the soil, takes the place of the mole, which is absent. Porcupines are troublesome in gardens. Among the reptiles, a tortoise (*Testudo*) destroys young cotton. The crustacean *Porcellio ornatus* M. Edw. is very harmful to crops, especially young cotton. The slug *Agriolimax buchar* Simroth is bad on cabbage, etc. A much larger slug (*Parmacella levanderi* Simroth) is also complained of. Attention is also paid to the birds; I noticed mounted specimens of the beautiful *Pastor roseus*, useful as an enemy of grasshoppers. The Director of the Station is V. J. Plotnikoff, who is specially interested in Acridiidae. A very fine account of the grasshoppers of the region, by Uvarov of the British Museum, has been published by the Station. N. P. Nevsky, working at the Station, is a specialist in Aphididae. Just as I was leaving Tashkent I was informed that he had named a new aphid after me, as a memento of my visit. I met also Miss Alexandra D. Archangelsky, a student of Coccidae, who works in the Museum at Samarkand. She has found some very interesting new species, as might be expected in such a region; I was shown one which superficially appeared to be a *Takahashia*, and another of an unknown, perhaps new, genus. The various species of *Tamarix*, native in the region, are prolific in interesting Coccidae. As we passed through the thorny desert in the train, the pink flowers of tamarisk was almost the only blossoms visible in a dry and dusty landscape.

The Station has a very fine set of glass-covered mounts, showing the life-histories of all the local injurious insects. As I went over these I noted the principal ones, and was informed concerning their economic status. A partial catalogue may be of interest, especially as showing that even in this remote region the pests are in large part identical with those familiar in America.

ARACHNIDA—*Eriophyes piri* Pag., *E. vitis* Land, and *Tetranychus* labelled *telarius*, but it was explained to me that this determination had to be revised in the light of recent American work.

ORTHOPTERA—*Dociostaurus moroccanus* Thunb is their most harmful insect, but *Locusta migratoria* L. has been made the subject of a special bulletin. They were breeding the latter species in cages, and made the remarkable observation that the young hoppers were red when bred in numbers together, but green when bred alone. *Gryllus desertus* Pallas is an ordinary looking cricket. Mr. Plotnikoff specially called my attention to the very interesting (though economically unimportant) genus *Consphyma*, consisting of wingless forms recalling our short-winged *Melanoplus*. This genus includes a large number of local species; every mountain mass has two or three species, apparently. Fourteen species were known up to this year, but during the year Plotnikoff has found four new ones, and doubtless many others exist.

LEPIDOPTERA. *Carpocapsa pomonella* infests apples as with us. *Caradrina exigua* is a pest on alfalfa, *Heliothis obsoleta* is injurious to cotton, *Pieris brassicae* is not very destructive to cabbages; *Plutella maculipennis* is much worse, *Ocneria dispar* is found in the mountains, and occasionally in the valleys. Various species of *Coleophora* are troublesome; they have not yet been fully investigated. N. N. Filipjev of Leningrad has recently published one of them (*C. hemerobiola*) as new, showing that the female genitalia as well as those of the male afford excellent specific characters. *Cosmia subtilis* Stgr. is injurious to apricot. *Biston cinerarius* Ersch. is bad on mulberry. *Agrotis segetum* is an important cutworm, but other species occur.

DIPTERA. Several species of *Anopheles* exist, and malaria is endemic. *Oscinella frit*, *Mayetiola destructor*, *Pegomyia hyoscyami*, *Agromyza flaveola* and *Stenodiplosis panici* are noted among the Diptera injurious to crops.

HYMENOPTERA. *Eriocampoides limacina* is an important pest.

HEMIPTERA. *Dolycoris penicillatus* Horvath is a pentatomid bug of considerable importance; it usually lives on trees, but descends in swarms on the wheat and other crops. *Psylla piricola* is a serious pest on fruit trees. *Eriosoma lanigerum* is very injurious, and has been made the subject of a special bulletin. Other notable aphids are *Aphis pomi*, *A. gossypii*, *Pterschloroides persicae*, *Hyalopterus pruni*, etc. I was surprised to see a species of *Forda* forming galls. The collection of local Coccidae at the station, so far as identified, includes the following: *Gueriniella serratulae*, *Orthezia urticae*, *Pulvinaria artemisiae*, *P. betulae*, *P. orientalis* Nassonov (on *Salsola*), *P. pistaciae* (n. sp.), *Lecanium corni*, *L. persicae*, *Physokermes unifasciatus* Arch., *P. coryli* Ldgr., *Lecanium bituberculatum*, *Gossyparia ulmi*, *Asterolecanium variolosum*, *Aulacaspis*

rosae, *Eriococcus spurius* Ldgr., *Leucaspis riccae*, *Chionaspis salicis*, *Aspidiotus ephedrarum* Ldgr., *A. transcaspiensis* Marl. *A. brittanicus* Newsh (Miss Archangelsky says she is not quite sure of this determination), *Lepidosaphes ulmi*, *L. juniperi* Ldgr.

COLEOPTERA. *Rhynchites auratus* causes a loss of two million roubles a year (a million dollars) to the apricot crop. *Galerucella luteola* is bad on elms. *Zabrus gibbus* (Carabidae) was discovered to be injurious last year. *Phytonomus variabilis* infests alfalfa. *Potosia marginicollis* Pallas is a handsome *Cetonia*-like scarabaeid, which injures fruit, especially apples. *Aeolestes* (or *Pachydissus*) *sartus* is a troublesome cerambycid borer in wood. The larvae of *Polyphylla adspersa* Motsch attack the roots of plants. The chrysomelid *Agelastica orientalis* Baly occurs on various trees.

A species of thrips is very bad on cotton.

In addition to the central station, there are fifteen local stations, each for the investigation of some particular problem or set of problems. About seven kilometers from Tashkent is a very good cotton-breeding station, where problems connected with cotton are intensively studied.

The workers at the station highly value the American publications on Economic Entomology, and welcome American cooperation. With conditions so similar to those in certain parts of the United States, and so many pests in common, it is obvious that there should be many opportunities for advantageous cooperation, as for instance in reference to matters of biological control.

COMMON NAMES OF INSECTS APPROVED FOR GENERAL USE BY AMERICAN ASSOCIATION OF ECONOMIC ENTOMOLOGISTS

SECOND SUPPLEMENT TO LIST APPEARING IN VOLUME 18, PAGES 521–545, 1925

The following list of common names was prepared by the Committee on Nomenclature of the American Association of Economic Entomologists in conformity with instructions given by the Association at its last regular meeting. A list of 56 names was submitted to the members of the Association and of these names the following 42 have met with their approval:

Key to Symbols

A—Acarina	H— Hemiptera	L— Lepidoptera
C—Coleoptera	Hy—Hymenoptera	M—Miscellaneous
D—Diptera	N— Neuropteroids	O— Orthoptera

Insects Listed by Common Names

American dog tick A	Dermacentor variabilis Say
Apple sucker H	Psylla mali Schmid.
Blueberry flea beetle C	Haltica torquata Lec.
Brown dog tick A	Rhipacephalus sanguinius Latr.
Cattle biting louse M	Trichodectes bovis L.
Cat flea M	Ctenocephalus felis Bouché
Chicken body louse M	Menopon stramineum Nitz.
Chicken head louse M	Lipeurus heterographus Nitz.
Chigger A	Trombicula irritans Riley
Clover seed midge D	Dasyneura leguminicola Lint.
Corn root webworm L	Crambus caliginosellus Clem.
Cotton leaf worm L	Alabama argillacea Hbn.
Cottonwood leaf beetle C	Lina scripta Fab.
Cowpea aphid H	Aphis medicaginis Koch
Dog flea M	Ctenocephalus canis Curtis
Eastern field wireworm C	Pheletes ectypus Say
Eggplant flea beetle C	Epitrix fuscula Crotch
Fire brat M	Thermobia domestica Pack.
Fluff louse M	Goniocotes hologaster Nitz.
Fork-tailed bush katydid O	Scudderia furcata Brun.
Green-striped maple worm L	Anisota rubicunda Fab.
Horse biting louse M	Trichodectes equi L.
House centipede M	Scutigera forceps Raf.
Itch mite A	Sarcoptes scabiei DeG.
Mormon cricket O	Anabrus simplex Hald.
Nose bot fly D	Gastrophilus haemorrhoidalis L.
Olive fruit fly D	Dacus oleae Rossi
Prairie grain wireworm C	Ludius aereipennis Kby.
Rose leafhopper H	Empoa rosae L.
Rose root gall Hy	Diplolepis radicum O. S.
Scab mite A	Psoroptes communis Fürst.
Sheep bot fly D	Oestris ovis L.
Silver fish M	Lepisma saccharina L.
Sorghum midge D	Contarinia sorghicola Coq.
Sorghum webworm L	Celama sorghiella Riley
Southwestern corn borer L	Diatraea grandiosella Dyar
Steel-blue ladybeetle C	Orcus chalybeus Bdv.
Strawberry root aphid H	Aphis forbesi Wied.
Two-spotted ladybeetle C	Adalia bipunctata L.
Throat bot fly D	Gastrophilus nasalis L.
Webbing clothes moth L	Tineola biselliella Hum.
Wheat joint worm Hy	Harmolita tritici Fitch

Insects Listed by Scientific names

Adalia bipunctata L	Two-spotted ladybeetle
Alabama argillacea Hbn	Cotton leaf worm
Anabrus simplex Hald	Mormon cricket
Anisota rubicunda Fab	Green-striped maple worm

Aphis forbesi Wied	Strawberry root aphid
Aphis medicaginis Koch	Cowpea aphid
Celama sorghiella Riley	Sorghum webworm
Contarinia sorghicola Coq	Sorghum midge
Crambus caliginosellus Clem	Corn root webworm
Ctenocephalus canis Curtis	Dog flea
Ctenocephalus felis Bouché	Cat flea
Dacus oleae Rossi	Olive fruit fly
Dasyneura leguminicola Lint	Clover seed midge
Dermacentor variabilis Say	American dog tick
Diatraea grandiosella Dyar	Southwestern corn borer
Diplolepis radicum O. S	Rose root gall
Empoa rosae L	Rose leafhopper
Epitrix fuscula Crotch	Eggplant flea beetle
Gastrophilus haemorrhoidalis L	Nose bot fly
Gastrophilus nasalis L	Throat bot fly
Goniocotes hologaster Nitz	Fluff louse
Haltica torquata Lec	Blueberry flea beetle
Harmolita tritici Fitch	Wheat joint worm
Lepisma saccharina L	Silver fish
Lina scripta Fab	Cottonwood leaf beetle
Lipeurus heterographus Nitz	Chicken head louse
Ludius aereipennis Kby	Prairie grain wireworm
Menopon stramineum Nitz	Chicken body louse
Oestris ovis L	Sheep bot fly
Orcus chalybeus Bdv	Steel-blue ladybeetle
Pheletes ectypus Say	Eastern field wireworm
Psoroptes communis Fürst	Scab mite
Psylla mali Schmid	Apple sucker
Rhipacephalus sanguinius Latr	Brown dog tick
Sarcoptes scabiei DeG	Itch mite
Scudderia furcata Brun	Fork-tailed bush katydid
Scutigera forceps Raf	House centipede
Thermobia domestica Pack	Fire brat
Tineola biselliella Hum	Webbing clothes moth
Trichodectes equi L	Horse biting louse
Trichodectes bovis L	Cattle biting louse
Trombicula irritans Riley	Chigger

Scientific Notes

***Vitula serratilineella* Ragonot on Dried Fruit in California.** In 1903, Dyar[1] stated that dried fruit received at the Department of Agriculture from Santa Clara County, California, was found to be infested by larvae of *Vitula serratilineella* Rag. This article is chiefly descriptive of the egg and the larva of this insect.

During the past three years, an occasional specimen of an unknown moth has been taken in the vicinity of stored dried fruit but efforts to breed the species were unsuccessful, mainly because of scantiness of material. In the fall of 1924, dead specimens were taken among stored prunes in a warehouse at San Francisco subsequent to hydrocyanic acid gas fumigation. During the summers of 1925 and 1926, two or three specimens were also collected at Fresno. In February, 1927, specimens of an unknown larva were brought to the writers' attention by Mr. James MacKay, superintendent of the American Seedless Raisin Company's packing plant at Del Rey. These larvae attracted his attention by being considerably larger than larvae of *Plodia interpunctella* Hbn., the common dried fruit pest. They were reported as occurring on stored raisins, but in very small numbers. Two adults, both males, emerged about the middle of April from the larvae sent Mr. MacKay. At Fresno, two females were collected at fig packing establishments on March 16 and 27, respectively. From the 94 eggs obtained from the latter female rearings were started and the following life-history data obtained.

The eggs are placed on raisins in a manner very similar to those of the Indian-meal moth. Eggs laid at the end of March hatched in 10 to 11 days. The resulting larvae pupated after 52 to 108 days, averaging about 69 days for the larval stage. The pupal period lasted 8 to 12 days, the adults emerging from June 11 to July 1. The preoviposition period ranged from 1 to 10 days, but was mostly 1 to 3 days.

Each of 10 females deposited from 32 to 200 eggs, averaging about 102 eggs per female. During late June and early July these eggs hatched in 4 to 6 days. Emergence of adults of the second summer generation began on September 2.

From these fragmentary data we see that the species breeds slowly in the San Joaquin Valley, having only two generations during the long summer, and a total of three generations throughout the year. The species overwinters in the larval stage. In our rearings the average number of eggs deposited was small, the hatch very poor, and the larval mortality great. These circumstances together with its slow development appear to account for the scarcity of the species in the Fresno district.

J. C. Hamlin and W. D. Reed,
Bureau of Entomology, Fresno, California.

Calcium Arsenate as a Cause of Aphis Infestation. When dusting with calcium arsenate became prevalent for control of the boll weevil in cotton, it was noticed that excessive applications of calcium arsenate were often followed by heavy infestations of the cotton louse (*Aphis gossypii* Glov.). The actuality of this relation was demonstrated in field experiments planned and directed by Mr. B. R. Coad, in charge of cotton insect investigations of the Bureau of Entomology, at Tallulah, La.

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[1]Note On A California Fruit Moth, by Dyar, H. G., Proc. Ent. Soc. Wash., Vol. 5, p. 104, 1903.

These extensive experiments, conducted from 1924 to 1926, inclusive, and involving 65 acres of plats, showed the dependence of aphis multiplication upon the number of applications of calcium arsenate and the time of the season at which the applications were made. They showed also that the regular, or commercial, number of applications did not produce injurious infestations, and that an infestation could easily be checked with a nicotine mixture.

The causal connection between calcium arsenate dusting and aphis multiplication has been a puzzle. The evident hypothesis is that the arsenate diminishes factors that normally check the reproduction of the lice. We could find no evidence in our experiments of 1925 and 1926 that plant condition, meteorological influences or disease had anything to do with the matter; so we studied chiefly the natural enemies of the louse. The insect enemies number some 60 species, dominated as usual by Coccinellidae, Syrphidae, Chrysopidae and parasitic Hymenoptera.

One might think that calcium arsenate would operate to kill off the predatory enemies of the cotton louse. As a matter of fact it did not. Coccinellids, syrphids and chrysopids were conspicuously more abundant on dusted plats than on check plats, and sweepings showed that these predators increased in number with their host.

For the purpose of catching insects that might be killed by dusting, cloths were spread under cotton plants and held down under each plant by a fence-like frame of boards, four feet square. After dusting, these "trays" were examined every few hours and for several days, with the result that dead insects were not found in them. A few insects or spiders entered the trays accidentally, but that was all. The predators were not killed by the dusting.

Of hymenopterous parasites, *Aphidius testaceipes* was most abundant, attaining its maximum numbers June 17–July 1 and August 4–15, in 1925. Lice parasitized by this species were scraped from cotton leaves, incidentally with more or less calcium arsenate, and kept in Petri dishes for the study of emergence. The parasites upon emerging struggled about in the arsenate and died. They died also in the open air in the presence of calcium arsenate. Under a microscope the dust could be seen on the legs and body, abundantly when there was dew on the leaves, and the parasites often drew the feet through the mouth. Grains of arsenate were not observed in the spiracles, and most of the grains were too large to enter the spiracles. There remains, however, a possibility of spiracular poisoning or clogging. The parasites were killed not only by calcium arsenate but also by other dusts, some of which were inert. Calcium arsenate killed them in 21 minutes, on an average; calcium hydroxide, in 33.7 minutes; calcium carbonate, with two per cent of Paris green, in 38.1 minutes; corn starch, in 65 minutes; and calcium carbonate, in 66 minutes.

A second important primary parasite of the cotton louse was *Pachyneuron siphonophorae*. This was most abundant during the first week of July and in September and October, when *Aphidius testaceipes* was uncommon. *Pachyneuron* was killed in the same manner as *Aphidius* by dusts on the leaves. Calcium arsenate killed it in 38 minutes and calcium carbonate, in 68 minutes; whereas corn starch required from 6 to 12 hours.

The effect, then, of dusting with calcium arsenate was to favor the multiplication of the cotton louse by reducing the numbers of its most important parasitic enemies.

Before parasitism appeared, however, the cotton louse was much more abundant on dusted plants than on undusted. Winged lice appeared on the former a few hours

after dusting, but not on the latter; and two dustings, three days apart, gave a moderate infestation in a week or so. This had to be accounted for.

A clue was found, at the time of dusting with hand guns, when winged female lice were now and then seen to fly like a shot at patches of arsenate on the leaves and remain there. This suggested tests for positive phototropism.

Single plants which were dusted became heavily infested; but the surrounding undusted plants were not infested. Infestations were induced not only by means of calcium arsenate but also with calcium carbonate, starch and flour, on individual plants. Then large-scale dusting experiments were made, for the comparison of calcium arsenate with another dust, that should be white, but inert. Cuts of cotton were laid out, each of about three acres, divided into three equal plats: (1) a check plat; (2) a calcium-carbonate plat; (3) a calcium-arsenate plat. The percentages of infestation were arrived at by means of a system which expressed a composite figure representing: (1) the percentage of plants infested, (2) the number of infested leaves per plant, and (3) the average infestation per leaf. In estimating the leaf infestation ten grades of infestation, represented by a standard series of ten photographs, were used. In 1925 both dusted plats developed eventually 100 per cent infestation, probably for the reason that the only immediately available carbonate contained 2 per cent of Paris green (for use in *Anopheles* dusting). In 1926, pure carbonate was used, on the two cuts, M and K. Cut M was dusted seven times, July 3 to August 14, using each time an average of 17 pounds of calcium carbonate and six pounds of calcium arsenate. The initial and final percentages of infestation were as follows:

	1. Check	2. Calcium carbonate	3. Calcium arsenate
July 3 (original infestation).....	0.7	0.3	0.1
Aug. 20 (final infestation).....	38.	78.	95.

The high infestation of the calcium-carbonate plat was probably due to the fact that the plat had to be poisoned for the leaf worm on August 11.

Cut K received no Paris green, and was dusted eight times, June 11 to August 14, with 13 pounds of Calcium carbonate and 8 pounds of calcium arsenate. The percentages of infestation were:

	1. Check	2. Calcium carbonate	3. Calcium arsenate
June 11 (original).....	3.3	2.	1.3
Aug. 20 (final).....	18.	25.2	69.

Always the calcium-arsenate plat and the calcium-carbonate plat became infested at the same time after dusting, and the infestation developed equally on the two plats until parasitism began; thereafter infestation became gradually greater on the calcium-arsenate plat than on the calcium-carbonate plat.

As another phototropic test, plants were dusted with calcium arsenate that had been colored green to resemble leaves. These plants remained uninfested; but adjacent plants dusted with white arsenate became infested in three days. In five to ten days, however, the green calcium-arsenate faded to almost white in the sunlight; then infestation came.

It has often been observed that aphis infestation becomes more intense on small areas of dusted cotton (as on experimental plats) than on large dusted areas of hundreds or thousands of acres. An explanation of this would be that the positive phototropism of the aphids causes them to concentrate on white areas of cotton

that are relatively small; but where all the cotton in a district is whitened, the aphids have no opportunity for selection.

SUMMARY.—Excessive applications of calcium arsenate are often followed by heavy infestations of the cotton aphis. The initial infestations are due to the positive phototropic reaction of winged females to white substances, such as calcium arsenate, calcium carbonate, starch or flour. A heavy infestation is built up, not by the destruction of predators by calcium arsenate, but by the killing of hymenopterous parasites when they emerge in the presence of the arsenical. They are killed also, though more slowly, by calcium hydroxide, calcium carbonate and corn starch.

J. W. FOLSOM, *Entomologist, Cotton Insect Investigations, Bureau of Entomology.*

***Pseudococcus maritimus* Ehrhorn, a pest of Gladiolus and Calla.** In late May, 1925, several hundred dormant Gladiolus corms from storage were brought into the laboratory by a local florist whose stock of 1500 bulbs was heavily infested with mealy bugs. The insects, their egg masses, and the fluffy wax, nearly covered the corms beneath the outer covering of dead leaf scales. All of the corms were shrivelled, due, evidently, to the feeding of the mealy bugs as no scab or other disease seemed to be present. The florist stated that he observed an occasional mealy bug on the roots when digging the crop the preceding fall and that breeding had progressed in the storage cellar during the winter.

About the same time a similar infestation of mealy bugs on 2000 Gladiolus corms were examined at a greenhouse in Philadelphia where they were being stored over winter beneath a bench. In early March the florist had placed near the Gladioli about 300 Calla Godfrey plants for drying off, after knocking them out of the pots and leaving the soil ball about the roots intact. At the time of the writer's visit, the corms of the Callas within the soil ball were very heavily infested with a mealy bug and the whole plant parts were in a badly shrivelled condition similar to that of the Gladioli. Neither florist attempted to eradicate the insects as a means of saving their stock but destroyed it because they considered the injury too severe for recovery of the plants.

In July, 1927, a third infestation, but very light and apparently doing no damage, was found in some stored Gladiolus stock at Willow Grove.

Material from the 1925 infestations were examined and the mealy bug was identified as *Pseudococcus maritimus* Ehrhorn by Mr. F. M. Trimble, Chief Nursery Inspector, Bureau of Plant Industry, Harrisburg, Pa. Specimens from the 1927 infestation were similarly identified and this determination was verified by Mr. Harold Morrison, U. S. Bureau of Entomology. Since there were no available records of this insect being an economic pest it was considered advisable to investigate methods for its control. In 1925 a few tests were conducted with infested Gladioli and the following results were observed.

A. Hot water immersion of corms.

May 13.				Effect on insect after 4 days
Water 44–45° C.	10 minutes exposure	25 corms	6 dead 85 living	Eggs hatched later.
" 47–48° C.	10 " "	25 "	67 " 0 "	50% of eggs hatched later.
" 51–52° C.	10 " "	25 "	84 " 0 "	No eggs hatched.
Check—no treatment		60 "	0 " 60 "	Eggs hatched later.

B. Immersion in Kerosene Nicotine Oleate.

May 13.

Water 20° C. 5% emulsion, 10 min. ex.	25 "	38 "	0 "	No eggs hatched later.
" 20° C. 2.5% " 10 "	25 "	33 "	11 "	Eggs hatched later.
Check—No treatment	50 "	0 "	41 "	"

C. Immersion in Ivory Soap Emulsion (1 gram per 100cc.)

May 13.

Water 20° C. 10 minutes exposure	25 corms	10 "	86 "	Eggs hatched later.
Water 45° C. 10 " "	25 "	50 "	10 "	Eggs hatched later.

D. Nicotine Sulphate (1–800) plus Fish Oil Soap.
(2 lb. per 50 gal.)

May 13.

Water 20° C. 10 minutes immersion	25 corms	1 dead	165 "	Eggs hatched later.

After examining the insects, the corms with the mealy bugs still adhering were planted out of doors. However, all the corms including the checks were in such condition that only weak growths were made and these soon died down with the rotting of the roots. The preceding tests are therefore not presented as conclusive but merely as suggestions to others who may wish to eradicate this pest should it be encountered on stock less severely injured than was that at hand for our work.

FLOYD F. SMITH,
Willow Grove, Pennsylvania (Penna. Bureau of Plant Industry).

Lilac Leaf Miner, *Gracilaria syringella* Fabr. Lilac and privet leaves badly mined and curled were received in August from Mr. R. E. Horsey of Highland Park, Rochester. He stated that in some cases every leaf on a lilac bush was dried or curled up, while in others every leaf was infested and but little green tissue remained. Reared adults were identified by Dr. August Busck of the U. S. National Museum.

Later Mr. Horsey stated that this species has been reported from all over the city of Rochester and on August 28th he saw in the reservation at Niagara Falls, a number of lilacs infested with what he believes to be the same insect. Work of this species was also received the last of August from Albert P. Morse, Curator of Natural History, Peabody Museum, Salem, Mass., accompanied by the statement that the lilacs in that section looked quite disreputable.

E. P. FELT

Keeping Quality of Prepared Grasshopper Baits. Prepared grasshopper poison was studied and reported by D. B. Mackie in 1919 (California Monthly Bulletin, Vol. IX, No. 5–6, pages 194–197). A formula reported by Mr. Mackie as satisfactory in his tests consisted of:

White arsenic.....1 lb.
Finely ground orange pulp.....5 lbs.

This mixture was sealed in tin cans for storage and it was recommended, when used, to mix the contents of one can with 25 lbs., of bran and sufficient water to make up a mash of the desired consistency.

Successful tests with this material were made in Arizona and Colorado, as well as in California. It will be noted that no molasses was used but, instead of this, more orange pulp was used; otherwise, the ingredients were similar to the government formula.

The formula having been tested and found to be effective, the next interesting point is how long the material will keep. As far as my information goes, no records have been made of its keeping quality for longer than one year.

The devastating grasshopper, *Melanoplus devastator* Scud., became so abundant this summer that control measures had to be undertaken. Some prepared poison bait, which had been made in 1919 by Orange Products Company and had been stored for the past eight years on the ranch of Mr. G. H. Hecke, Director of Agriculture, was tried in this work.

The cans were in perfect condition except that the ends were bulged apparently from fermentation which had taken place within. The mash was prepared at greater than the recommended strength and broadcast in the usual manner. Much to our surprise, very successful results were obtained, equalling any that were obtained with freshly mixed material made with the government grasshopper bait formula using Paris Green.

It is evident from this observation that prepared grasshopper baits may be stored in tin cans indefinitely without losing their attractiveness or effectiveness for grasshopper control. The ease with which this material is mixed and the length of time it may be stored without deterioration makes it a valuable addition to our control materials.

FRANK E. TODD, *Entomologist, California State Department of Agriculture*

ENDOWMENT FUND NEWS

The endowment committee has invited one member in each State and in each Province in Canada to organize the members in his own territory to assist in raising the endowment.

The following have responded favorably:

Alabama—Prof. J. M. Robinson, Box 264, Auburn.
California—Prof. E. O. Essig, Agricultural Hall, Univ. of Calif., Berkeley.
Colorado—Prof. Geo. M. List, Agri. Exp. Station, Fort Collins.
Connecticut—Dr. W. E. Britton, Agri. Exp. Station, New Haven.
Georgia—O. I. Snapp, Bureau of Entomology, Fort Valley.
Indiana—Prof. J. J. Davis, Agri. Exp. Station, Lafayette.
Iowa—Prof. C. J. Drake, State College, Ames.
Mississippi—Prof. R. W. Harned, Agricultural College.
Nevada—Prof. C. W. Creel, Extension Div., University of Nevada, Reno.
New Hampshire—Prof. P. R. Lowry, Durham.
New Jersey—L. B. Smith, Moorestown.
North Carolina—Prof. Z. P. Metcalf, West Raleigh.
North Dakota—J. A. Munro, State College, Fargo.
Oregon—Prof. Leroy Childs, Hood River.
Utah—George I. Reeves, 473 Fourth Ave., Salt Lake City.
Virginia—Prof. W. J. Schoene, Agri. Exp. Station, Blacksburg.
Wisconsin—Prof. H. F. Wilson, University of Wisconsin, Madison.

Canada

Manitoba—Prof. Norman Criddle, Treesbank.
Quebec—Dr. W. H. Brittain, Macdonald College.
Saskatchewan—Prof. K. M. King, Entomological Laboratory, Saskatoon.

Replies from other States and Provinces will doubtless be received before this issue of the Journal is printed but the above list covers those that arrived before going to press.

One member of the Association suggests that when any member wishes to dispose of his library he might donate it to the Association so that it could be sold and the proceeds turned into the endowment fund. This idea might be adopted to advantage in cases where the books were located where they could be disposed of by some member of the Association without the necessity of incurring expense for long distance shipment. It is probable that there are members who have duplicate copies of rather rare books or reports that they would be willing to donate for the benefit of this fund. It is possible that some of the members might secure valuable collections of insects that could be handled in this way. The committee will welcome suggestions from any and all sources.

The endowment fund now totals over $5,000, which is an increase of over $1,000 during the past year.

One application for life membership has been received during the past month.

A. F. BURGESS,
Chairman, Endowment Committee

JOURNAL OF ECONOMIC ENTOMOLOGY

OFFICIAL ORGAN AMERICAN ASSOCIATION OF ECONOMIC ENTOMOLOGISTS

DECEMBER, 1927

The editors will thankfully receive news matter and other items likely to be of interest to our readers. Papers will be published as far as possible in the order of reception, except that papers of reasonable length may be accepted in the discretion of the editor for early publication at $2.50 per page for all matter in excess of six printed pages, a part page counting as a full page, this limit not including acceptable illustrations. Photo-engravings may be obtained by authors at cost.

Separates or reprints, if ordered, when the manuscript is forwarded, will be supplied to authors at the rates given below. Note that the number of pages in a reprint may be affected somewhat by the make-up, and that part of a page is charged as a full page. Carriage charges extra in all cases. Shipment by parcel post, express or freight as directed.

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The Fourth International Congress of Entomology is to be held in August, 1928, at Cornell University, Ithaca, N. Y. Previous Congresses have met at Brussels (1910), Oxford (1912) and Zurich (1925). Every important interest—educational, scientific and economic will be provided for in the program. Invitations have been forwarded through the state department to foreign governments to send representatives and later invitations will also be sent to the individual entomologists. A program will be arranged in which some of the leading entomologists of the world will take part. It is planned that in the forenoons throughout the week papers of general interest are to be read before the members of the Congress. In the afternoon there will be sectional meetings dealing with (1) Taxonomy, distribution and nomenclature, (2) Morphology, physiology and genetics, (3) Ecology, (4) Medical and Veterinary Entomology, (5) Economic Entomology with its subdivisions relating to forest, fruit, vegetable and cereal insects, bees, insecticides and appliances. According to the number of papers announced, each section may be subdivided or several sections may be united. Time will be arranged for an all-day visit to the Geneva Experiment Station where the forenoon will be spent in looking at the exhibit of spraying machinery and insecticides, in examining the methods and machinery used in controlling the European corn borer, and in observing a demonstration of airplane dusting. The afternoon will be devoted to a general program. In addition, the summer meeting of the New York State Horticultural Society will be held at Geneva on the same day. This will give visiting foreign entomologists more of an idea of the general interest of American

farmers in entomology. Certain afternoon excursions will also be made to nearby places of entomological interest, while immediately after the meetings some general excursions are planned to Niagara Falls, to entomological museums of eastern cities and to the laboratories of the U. S. Bureau of Entomology devoted to the study of the Gypsy and Browntail Moths, the European Corn Borer and the Japanese Beetle.

A record of unusual interest in relation to two leaders in entomological work is reproduced here. It is a tale of accomplishment we all admire, and an exposition of possibilities in scientific work.

After more than 33 years of service as chief entomologist of the United States Department of Agriculture, Dr. LELAND O. HOWARD retired October 17 as the chief of the Bureau of Entomology, and was succeeded by Dr. C. L. MARLATT, a member of the department since 1888, and who for the past five years has been associate chief in charge of the regulatory work of the bureau, and also chairman of the Federal Horticultural Board.

Dr. Howard is now in his fiftieth year of Government service, having joined the entomological branch of the Department of Agriculture in 1878 soon after his graduation from Cornell University. He retires as chief at his own request, but this does not mean retirement from service. He has passed his seventieth birthday, and has asked to be relieved of the administrative duties of his office, but proposes to devote his full energies to the field of entomological research in which he has long been recognized as perhaps the most distinguished investigator. His favorite fields are medical entomology and parasitology.

Dr. Howard was placed in charge of the entomological work of the department June 1, 1894. In the 33 years that have followed, the science of entomology has broadened tremendously and Dr. Howard has guided numerous activities which have been of great service to the American public.

Two campaigns with which Dr. Howard has been identified have captured the public fancy. He was a leader in the mosquito crusade. As early as 1892 he published results of experiments showing that certain types could be controlled by the use of kerosene, and when the mosquitoes were identified as disease carriers he was able to recommend methods of control. His publications on the house fly dating from 1896, to his book, The House Fly, Disease Carrier, in 1911, were largely responsible for the anti-house fly crusades all over the world in the last 20 years.

Dr. Howard is a member of the three great American associations of limited membership, the National Academy of Sciences, the American

Philosophical Society, and the American Academy of Arts and Sciences. He was Permanent Secretary of the American Association for the Advancement of Science for 22 years, and its president in 1920–21. He has been made honorary member of many foreign scientific societies and is the only American honorary member of the Academy of Agriculture of France, and received several decorations among which are the Cross, Chevalier de la Legion d'Honneur, and the Cross, Officer de l'Odre du Merite Agricole. He has been a delegate to many international assemblies and an officer of six scientific gatherings. In addition to bachelor's and master's degrees from Cornell, his doctorates include Ph.D. (Georgetown 1896), M. D. (George Washington, 1911), LL.D. (Pittsburgh, 1911), and Sc.D. (Toronto, 1920). The bibliography of his publications includes 941 titles.

Dr. Marlatt joined the Department of Agriculture in 1888 and has been closely associated with Dr. Howard's administration. When Dr. Howard was made chief Dr. Marlatt became assistant chief, and in 1922 associate chief in charge of regulatory work. He was instrumental in promoting the passage of the Plant Quarantine Act of 1912 and was appointed to administer it. Dr. Marlatt's specialties have been studies of scale insects, sawflies and periodical Cicadas, known as locusts.

He holds the degrees of B.S., M.S., and D.Sc., all from the Kansa State Agricultural College.

Obituary

FREDERIC LEONARD WASHBURN

Professor Frederic Leonard Washburn, chief of the division of entomology and State Entomologist for Minnesota from 1902 to 1918, died suddenly from a combined attack of flu and pneumonia at his lake residence, Mound, Minnesota, Saturday, October 15, 1927.

Professor Washburn received his A.B. from Harvard in 1882 and his A.M. (Harvard) 1895. He was instructor in Zoology at Michigan 1887–1888. In 1888 he was called to Oregon where he became entomologist and state biologist. In May 1902, he came to Minnesota as successor to Otto Lugger. He continued the series of reports begun by his predecessor. These reports, 7–16, were well illustrated and a number contain beautifully colored plates.

From 1918 until his retirement from University work in 1926, Professor Washburn retained his connection with the Minnesota division of

entomology as economic zoologist. He was particularly interested in birds and mammals. During the late war he took an active interest in Belgian hares in order to help increase the food supply of the country. As a result of these activities he produced a book on rabbit farming.

During his sojourn in the South Sea Islands he made many paintings of native scenery and life on the Islands, besides making a collection of insects. Upon his return to this country he gave lectures on life in the Islands which were profusely illustrated by colored lantern slides. It was the artistic temperament showing through, and upon his retirement he immediately started devoting his time to painting, lecturing and writing. He was perfectly happy in this environment and it was expected that he would have many happy years in the work he loved so well.

F. L. Washburn was president of the American Association of Economic Entomologists for 1911. He is the author of "Injurious Insects and Useful Birds" and the "Rabbit Book," both published by Lippincott. He was the first entomologist in this country to figure and describe the egg of the codling moth.

Current Notes

Dr. David L. Crawford is now president of the University of Hawaii.

Entomological News announces the death on August 8, 1927, of Mr. G. C. Champion at Woking, England.

The Japanese Beetle Laboratory, Riverton, New Jersey, has been moved to more commodious quarters at Moorestown, New Jersey.

Mr. H. J. MacAloney returned August 25, after working for three months in Canada under Dr. J. M. Swaine of the Entomological Branch, on the white pine weevil.

Dr. T. J. Headlee recently visited the entomological field laboratory at Chatham, Ontario, and discussed the value of parasites in the control of the Oriental peach moth.

Mr. M. A. Stewart, a student of the Siphonaptera, and formerly instructor in biology at the University of Rochester, has been appointed instructor in biology at Rice Institute, Houston, Texas.

Sir Arthur Everett Shipley, Vice-Chancellor of the University of Cambridge, England, distinguished zoologist and entomologist and a foreign member of this Association, died on September 22, aged 66 years.

Mr. E. R. de Ong has recently resigned from the University of California and is now engaged as consulting entomologist and in teaching in the Cora Williams Institute, Berkeley, Calif.

At the Idaho University and Station, Mr. W. E. Schull will serve as assistant professor of entomology and extension entomologist during the absence of F. E. Whitehead, who is at the Iowa College for graduate study during the year.

According to *Science*, E. O. Essig has been appointed professor of entomology at the University of California and entomologist of the Agricultural Experiment Station. Dr. Edwin C. Van Dyke has also been appointed professor of entomology at the same institution.

Science also reports that Assistant Professor A. E. Emerson, of the department of zoology of the University of Pittsburgh, who represented the University at the International Congress of Zoologists at Budapest, has returned from a year's study in Italy and Sweden.

Mr. Harold Compere, an entomologist at the Citrus Experiment Station of the University of California, Riverside, Calif., visited the Honolulu station of the Bureau on August 5. Mr. Compere was on his way for an extended stay in Australia in search of beneficial insects.

Mr. A. B. Gahan, of the Bureau of Entomology, sailed from New York on September 13 for an extended trip to Europe to study the types of parasitic Hymenoptera and consult with other specialists on this group. He planned to stop first at the British Museum.

Mr. C. B. Hutchings supervised the display of entomological exhibits at the Central Canada Exhibition, Ottawa, August 22–27, and the Canadian National Exhibition, Toronto, August 27 to September 10. Mr. Hutchings was assisted by several officers from Branch headquarters and from the laboratories at Chatham, Vineland, and Strathroy.

Dr. M. W. Blackman returned on September 1 to the New York State College of Forestry at Syracuse University. He had been with the Bureau as specialist in Scolytidae for the preceding 15 months, engaged in biological studies of the Black Hills beetle on the Kaibab and Colorado National Forests.

Messrs. A. F. Burgess, H. L. Blaisdell, and E. B. O'Leary, of the Bureau of Entomology, and H. L. McIntyre, Supervisor Forest Pest Control for the State of New York, held a meeting at Pittsfield, Mass., on August 24 to discuss cooperative plans of gipsy moth work in the State of New York.

Recent visits to the Boyce Thompson Institute for Plant Research have been made by the following entomologists: Mr. E. A. Richmond of Riverton, N. J.; Dr. I. M. Hawley of Salt Lake City, Utah; Mr. V. I. Safro of New York City; Prof. Robert Matheson of Cornell University, and Dr. W. H. Thorpe of Cambridge University, England.

According to *Science*, a banquet was held by the Czecho-Slovak Academy of Agriculture on August 15 in honor of its visiting honorary member, Dr. L. O. Howard, of the U. S. Bureau of Entomology. During the banquet, Professor Stoklasa, who

acted as toastmaster, spoke in appreciation of Dr. Howard's contributions to entomology.

Mr. G. F. Moznette, in charge of the pecan insect laboratory of the Bureau of Entomology at Albany, Ga., attended the twenty-sixth annual convention of the National Pecan Growers' Association, held at Shreveport, La., on September 27-29, and delivered an address on "Factors Which Enter into the Successful Control of the Pecan Nut-Case Bearer."

Professor James G. Needham, head of the department of Entomology at Cornell University, has been granted sabbatical leave for the coming year and has sailed for China, where he will give a series of lectures on biological subjects at the Peking National University and Tsing Hua College, and an address at the opening of new buildings at the University of Yen Ching.

A conference of entomologists and commissioners of agriculture was held in the State House, Providence, R. I., on November 9, to consider certain phases of European corn borer control. The following entomologists were present: W. C. O'Kane, Durham, N. H.; R. H. Allen, Boston, Mass.; Harold L. Bailey, Bradford, Vt.; A. E. Stene and Harry Horovitch, Providence, R. I.; W. E. Britton, New Haven, Conn.; R. S. Clifton, Boston, Mass., and C. H. Hadley, Toledo, Ohio, of the Federal Bureau of Entomology.

Scouting for the European corn borer revealed that this insect is quite generally distributed in northern Ontario and southern Quebec. The infested area extends from St. Joseph's Island, Ontario, on the west to Batiscan Champlain County, Quebec, on the east. The most northerly collection was taken in Ontario near New Liskeard and Haileybury, in the Timiskaming district. Scouting in the provinces of Nova Scotia and New Brunswick failed to reveal any trace of the pest.

The new library at the Kansas State Agricultural College has recently been completed. Fairchild Hall, in which the library formerly was located, has been remodeled and improved facilities afforded for the Department of Entomology. A separate, advanced laboratory accommodating 12 graduate students, an enlarged collection room, three additional offices for the staff, and a general work room are the more important improvements. The lighting has been improved throughout, and most of the walls have been repainted.

Mr. H. G. Crawford returned to Ottawa from Western Canada on September 12, after visiting the laboratories at Lethbridge, Alta., Saskatoon, Sask., and Treesbank, Man., during the latter half of August and early September. En route, he conferred on entomological matters with Prof. E. H. Strickland of the University of Edmonton and Prof. A. V. Mitchener of the University of Manitoba. While in Winnipeg, he visited the Rust Research Laboratory. On September 23 he visited Professor Lawson Caesar at Guelph.

A conference was held on October 4 at the American Museum of Natural History in New York to discuss certain phases of the Japanese beetle quarantine. Entomologists present were: E. N. Cory, College Park, Md.; T. J. Headlee, New Brunswick, N. J.; H. B. Weiss, and V. I. Safro, Trenton, N. J.; W. C. O'Kane, Durham, N. H.; A. E. Stene, Kingston, R. I.; W. E. Britton and J. P. Johnson, New Haven, Conn.; E. P. Felt, Albany, N. Y.; and C. W. Stockwell, Riverton, N. J., C. H. Hadley,

Toledo, Ohio, and S. B. Fracker, Washington, D. C., representing the Bureau of Entomology.

Mr. E. G. Titus has resigned as Director of agricultural research with the Utah-Idaho Sugar Company, effective October 1, to accept a position as agricultural representative for the United States and Canada with the Dippe Brothers Seed Company of Quedlinburg, Germany. He expects to maintain headquarters at Salt Lake City with sub-stations in Colorado and Michigan and probably other points where experimental work will be carried on, to develop types of sugar beets and vegetables better adapted for the various sections and to endeavor to develop resistant types against the disease caused by Cercospora and other fungi, and against the curly leaf disease transmitted by the sugar-beet leaf-hopper, *Eutettix tenella* Baker, cooperating with all agencies possible.

The annual meeting of the International Great Plains Crop Pest Committee was held at the Dominion Entomological Laboratory at Saskatoon, Sask., August 31–September 1, under the chairmanship of Mr. Norman Criddle, and with Mr. K. M. King acting as secretary. Among those who attended the meetings were: R. A. Wardle of the University of Minnesota; J. A. Munro, entomologist of the Agricultural Experiment Station, Fargo, N. D.; N. C. Phillips and W. B. Mabee, of the Agricultural Experiment Station, Bozeman, Montana; Stewart Lockwood of the Billings Laboratory, Montana; A. V. Mitchener of the University of Manitoba; E. H. Strickland of the University of Alberta, and S. H. Vigor of the Field Crops Branch, Regina. In addition to Mr. Criddle the following Branch officers also attended: Messrs. H. G. Crawford, H. L. Seamans, K. M. King, Eric Hearle, H. E. Gray, K. E. Stewart, N. J. Atkinson, E. McMillan and A. P. Arnason.

Mr. R. A. Cushman, of the U. S. National Museum, left for Los Banos, Philippine Islands, early in October, to pack and ship to this country the large collection of insects bequeathed to the U. S. National Museum by the late C. F. Baker. This collection is reported to include more than 1,450 Schmitt boxes of pinned specimens, a large quantity of unmounted material, and an extended card index of references to Indo-Malayan entomology. It contains many types and hundreds of species new to the National collection. No one in the Islands could undertake the task of packing this collection, and because of its importance and to comply with the expressed wish of Dr. Baker, the Bureau is cooperating with the Museum in arranging for its safe transport to Washington. In order that Mr. Cushman may properly represent the Museum, he has been appointed Honorary Assistant Custodian of Hymenoptera. It is expected that he will be away from Washington until early in January.

The Department of Entomology of the Kansas State Agricultural College has the following graduate students at the present time: Chester B. Keck, B. S., K. S. A. C., 1926, who is working on the tarnished plant bug, with special reference to alfalfa; Wesley G. Bruce, B. S., K. S. A. C., 1918, who holds the Volck research scholarship under the Crop Protection Institute, and is working on Volck as a control for certain external animal parasites; C. E. Abbott, A. B., Wisconsin University, 1925, who is majoring in Morphology and Physiology, and is studying the rice and granary weevils to see why they are so difficult to kill in fumigations; J. Forrest Garner, B. S., K. S. A. C., 1926, who is majoring in Apiculture and is studying various methods of field treatment of American foulbrood and wintering bees in Kansas; C. B. Wisecup,

B. S., K. S. A. C., 1926, also majoring in Apiculture and studying honey products; J. E. Durham, B. S., K. S. A. C., 1927, who is studying the ring-legged earwig recently found in numbers in flour mills in Kansas, and George B. Wagner, who will finish the B. S. work February 1. There are also five other graduate students from other departments minoring in some phase of Entomology.

The Fourth Annual Conference of Connecticut Entomologists was held at the Agricultural Experiment Station, New Haven, on November 4. Forty-three were present. The following program was carried out: Present Organization of Entomological Work in Connecticut, by Dr. W. E. Britton, New Haven; A Contribution to Our Knowledge of Cucumber Beetles, by Dr. H. C. Huckett, Riverhead, N. Y.; Notes on the Life History of the Asiatic Beetle, by Dr. R. B. Friend, New Haven; A General Survey of Gipsy Moth Conditions, by A. F. Burgess, Melrose Highlands, Mass.; Gipsy Moth Conditions in Connecticut, by John T. Ashworth, Danielson; Spread of the European Corn Borer and the Establishment of Imported Parasites, by D. W. Jones, Arlington, Mass.; Present Status of the European Corn Borer in Connecticut, by M. P. Zappe, New Haven; The Japanese Beetle and the Parasites Which Have Been Established in This Country, by J. L. King, Moorestown, N. J.; Japanese Beetle Conditions in Connecticut, by J. Peter Johnson, New Haven; Some Notes on the Life History, Habits, and Methods of Control of *Aserica castanea*, by Prof. C. C. Hamilton, New Brunswick, N. J.; The Plum Curculio in Connecticut Apple Orchards, by Dr. Philip Garman, New Haven; Mosquito Elimination Work of the Season in Connecticut, by R. C. Botsford, New Haven.

Dr. S. P. Minkiewicz, entomologist of the Institute for Agricultural Research, Pulawy, Poland, spent the week of October 19–24, visiting the Division of Entomology at the University of Minnesota. Dr. Minkiewicz was especially interested in the studies in insect ecology being carried on at Minnesota and in examining the laboratory and apparatus for studying the reactions of insects under controlled temperature and humidity conditions.

Dr. R. N. Chapman, who has been in Europe for the past year on a Guggenheim fellowship, has returned to the United States and resumed his duties with the Division of Entomology at the University of Minnesota. While in Europe Dr. Chapman spent the greater part of his time in studies on the "Biotic Potential of Insects." He also had the opportunity of visiting a large number of institutions in Europe where Entomology is taught or where research work is carried on.

Mr. F. G. Holdaway of Adelaide, Australia, is spending the year of 1927–28 at the Division of Entomology, University of Minnesota, studying for an advanced degree.

Mr. Stanley Garthside, of Sydney, Australia, who has been studying for the past year on a fellowship in Forest Entomology, is spending the current year at the Division of Entomology, University of Minnesota.

Mr. Lucius B. Reed, a graduate of the Department of Entomology, Clemson College, South Carolina, has been appointed an assistant in the Division of Entomology, University of Minnesota, and is also studying towards an advanced degree.

Mr. L. W. Orr has been appointed instructor in the Division of Entomology at the University of Minnesota and will teach the classes in forest entomology at that station.

Mr. H. E. Gray of Lethbridge, Alberta, has been appointed an assistant in the Division of Entomology, University of Minnesota, and is also studying at that station for an advanced degree.

Mr. R. E. Ozburn of the department of entomology, Ontario Agricultural College, Guelph, Ontario, is studying for an advanced degree in the departments of Zoology and of Entomology at the University of Minnesota during the current year.

Mr. E. G. Reinhard has accepted a position with the Minnesota Board of Public Health and will be engaged in a study of the insects inhabiting the lakes of Minnesota in connection with a survey being carried on by the public health board. Mr. Reinhard is also carrying work towards an advanced degree in the departments of Zoology and of Entomology at the University of Minnesota.

Mr. Allen McIntosh has resigned his assistantship in Zoology at the University of Minnesota and has accepted a position with the Department of Zoology at the University of Wyoming.

Dr. S. A. Graham has resigned his position as Assistant Professor of Forest Entomology at the University of Minnesota and has accepted a position as Associate Professor of Forest Entomology at the University of Michigan. Dr. Graham will be connected with the new school of forestry at that institution.

Professor J. S. Houser, Director of the Department of Entomology, Ohio Agricultural Experiment Station, Wooster, Ohio, visited the Division of Entomology of the University of Minnesota, November 5 to 8, inspecting the laboratories for the control of temperature and humidity in connection with the studies of insect ecology.

Mr. H. L. Seamans of Lethbridge, Alberta, visited the Division of Entomology of the University of Minnesota, November 5 to 8, and conferred with various members of the department regarding problems in entomological research.

Apicultural Notes

The fall meeting of the Connecticut Bee-Keepers Association was held at the State Capital, Hartford, on October 15. The principal speakers were R. B. Willson, Allen Latham, and Rev. A. W. Canney.

Messrs. C. B. Keck, Forrest Garner, and C. B. Wisecup, graduates of the Kansas State Agricultural College, 1926, are specializing in apiculture in the Department of Entomology at the Kansas State Agricultural College.

The annual meeting of the American Honey Producers' League will be held in San Francisco, California, on January 25, 26 and 27. In connection with this meeting there will be inaugurated an annual national honey exposition.

An item of economic interest is the recent great increase in the exportation of honey. This increase parallels the recent activities of various governmental agencies in promoting foreign trade in honey. During the fiscal year ending June 1926, only about three million pounds of honey was exported as against about eleven million pounds for the year ending June 1927.

A cooperative honey marketing association has been formed in Ohio, based on one of the commercial beekeepers' associations. As the members of this association

have been working together for a long time, not having missed a monthly meeting in ten years, the new organization should be successful. All the honey sold by the association will be graded according to the United States grades.

Mr. James I. Hambleton, of the Bee Culture Laboratory of the Bureau of Entomology, attended the meetings of the Louisiana State Beekeepers' Association held at New Orleans on November 14 and 15. He also inspected the flood relief work done in the interest of Louisiana beekeepers. Beekeepers from the North have aided beekeepers in the flooded regions by donating packages of bees. The express companies transported these donations free of charge. The American Red Cross also made cash funds available for the beekeeping relief work.

The Bee Culture Laboratory, of the Bureau of Entomology, in using the Standard Honey Color Grader, has found that washing the honey trough after grading a sample is greatly facilitated by using a dam of rubber to confine the honey to the part of the trough required for that particular sample, thus keeping the honey out of the narrow end of the wedge, which is the difficult part to cleanse, the narrow part being required only for the darker honeys. Pieces of rubber cut from an ordinary eraser answer the purpose excellently.

Dr. W. W. Alpatov, of the University of Moscow, one of the outstanding apicultural workers of Russia, is in this country pursuing his work on variability in the honeybee. He is particularly desirous of continuing his work on variability in this country because of the same distinct advantages offered in the United States, as in Russia, by the great range in latitude. The work here is being done with Professor Raymond Pearl of the Institute for Biological Research at Johns Hopkins University. During the past summer Dr. Alpatov was at Cornell University with Professor E. F. Phillips.

Mr. Lloyd M. Bertholf, Professor of Biology at Western Maryland College, has been granted leave of absence to study at Johns Hopkins University, where he has been awarded the Bruce fellowship. He will continue his work on the reaction of the honeybee to light of varying intensity and color. During the past summer he has been employed as a temporary Junior Biologist in Apiculture at the Bee Culture Laboratory of the Bureau of Entomology. A recent issue of the *Journal of Agricultural Research* contained a paper by Professor Bertholf entitled "The Utilization of Carbohydrates as Food by Honeybee Larvae." This paper is based on work done at the Bee Culture Laboratory during a previous summer. Professor E. F. Phillips of Cornell University, in the same issue of this journal, also has a paper which deals with the utilization of carbohydrates by the adult honeybee.

Notes on Medical Entomology

According to *Science*, the Harben gold medal of the Royal Institute of Public Health has been awarded for 1928 to Sir Ronald Ross in recognition of his eminent services to public health.

Mr. F. C. Bishopp has been transferred from Dallas, Texas, to Washington, D. C., and placed in charge of the experimental work on insects affecting man and animals. Mr. E. W. Laake has been placed in charge of the Dallas laboratory.

Professor R. A. Cooley spent a few days in Washington during early November conferring with various officials relative to his work on the Rocky Mountain spotted fever tick problem and especially that phase of it relating to the propagation of tick parasites.

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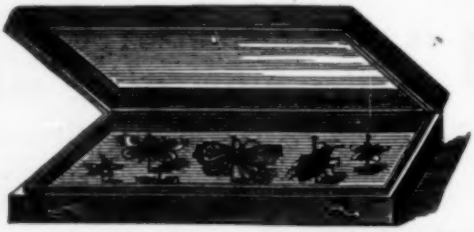

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The 40th annual meeting of the American Association of Economic Entomologists will be held at Nashville, Tenn., on the above-named dates. The meeting of the Section of Plant Quarantine and Inspection will be held Tuesday, December 27. The Section of Apiculture will open its meeting at 3 P. M. Tuesday and continue through that day and conclude with a session Wednesday morning.

The opening business session of the general Association and address of the President will be held Wednesday afternoon. The entomologists' dinner has been arranged for Wednesday at 7 P. M. On Thursday morning, December 29, there will be readings of papers before the general Association; in the afternoon a joint session will be held with the Cotton States Branch; at 8 P. M., there will be a meeting of the extension entomologists and Insect Pest Survey. Friday will be devoted to reading of papers before the general Association. The reading of papers will continue Saturday morning and the session will conclude with final business. If there proves to be ample time for presentation of papers and the transaction of final business by the close of the Friday afternoon session, it may not be necessary to continue into Saturday. This Association and its sections will meet in North Gymnasium, Southern Y. M. C. College, on Hillsboro Road, opposite Vanderbilt University.

Sectional Meetings

The meeting of the Section of Plant Quarantine and Inspection will be held at 9:30 A. M., Tuesday, and will continue until 3 P. M. The Section of Apiculture will meet at 3 P. M. and conclude with a session Wednesday morning.

Other Meetings

The annual meeting of the American Association for the Advancement of Science, its sections and associated societies, will be held December 26 to 31, 1927.

The Entomological Society of America will open its meeting on Tuesday morning, December 27, and will continue through Wednesday, December 28. The annual public address before that society will be delivered by Prof. H. T. Fernald, Amherst, Mass., on Tuesday evening at 8 o'clock. Members of this Association are especially invited to attend this session.

The extension entomologists and Insect Pest Survey will hold a meeting on Thursday, December 29, at 8 P. M. Details of this meeting will be announced at the day session. The Crop Protection Institute will probably have an evening meeting, the details of which will be announced later.

Hotel Headquarters

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Dinner

The entomologists' dinner will be held at the Hermitage Hotel on Wednesday evening, December 28, at 7 o'clock. All entomologists are cordially invited to attend.

Membership

Applications for membership can be secured from the Secretary or from the Committee on Membership. These should be filled out, properly endorsed, and filed with the Membership Committee on or before December 28. Each application must be accompanied with fee of $4.00 to cover dues and subscription to the JOURNAL for the year following election.

Exhibits

Members are requested to make exhibits of appliances, apparatus, photographs, maps or models demonstrating life history or control methods in preventing insect damage. Such exhibits will be displayed near the meeting room. Those wishing to send exhibits should do so in advance and should correspond directly with G. M. Bentley, State Entomologist, Knoxville, Tenn., who is in charge of local arrangements for the Association.

A. A. A. S.—Membership

Special privilege is granted this year to all our members to join the American Association without payment of the usual entrance fee. Application cards available through the Secretary of that organization.

Program

SECTION OF PLANT QUARANTINE AND INSPECTION

J. H. MONTGOMERY, *Chairman* W. B. WOOD, *Secretary*

Tuesday Morning Session, December 27, 9:30, North Gymnasium, Y. M. C. College

Address by the Chairman, J. H. Montgomery, Gainesville, Florida.

1. The National Plant Quarantine Board. Wilmon Newell, Gainesville, Fla.
2. REPORTS OF REGIONAL BOARDS:
   - The Plant Conference Board of the Middle Atlantic and Northeastern States. T. J. Headlee, New Brunswick, N. J.
   - The Central States Advisory Plant Board. L. Haseman, Columbia, Mo.
   - The Southern Plant Quarantine Board. R. W. Harned, A. & M. College, Miss.
   - The Western Plant Quarantine Board.

Program

Tuesday Afternoon Session, December 27, 1:30

READING OF PAPERS AND DISCUSSIONS

3. ACTIVITIES OF THE FEDERAL HORTICULTURAL BOARD:
   - Recent Developments in Federal Plant Quarantine. C. L. Marlatt, Washington, D. C.
   - Progress in Preventing the Spread of the Cornborer. H. N. Worthley.
   - The Present Status of the Pink Bollworm and the Thurberia Weevil. G. G. Becker, Little Rock, Ark.
   - The results of Control Measures in Preventing the Spread of Three Imported Insects: the Japanese Beetle, the Asiatic Beetle and the Green Garden Beetle. L. B. Smith, Moorestown, N. J.
   - Narcissus Inspection Problems. S. B. Fracker, Washington, D. C.

Developments in the White Pine Blister Rust Situation. S. B. Detwiler.

Progress of the Mexican Fruit Worm Eradication. A. C. Baker, Washington, D. C.

4. The Mediterranean Fruit Fly—Observations of a Fruit Grower. A. C. Hardison.

5. Pacific Port Inspection. L. A. Strong, Sacramento, Calif.

6. Progress in the Eradication of Citrus Canker and Remarks on the Present Status of the Potato Wart Disease. Karl F. Kellerman.

7. Shall the Station Entomologist Also Direct the State Regulatory Work? L. Haseman, Columbia, Mo.

8. Pear Blight Eradication in Northwest Arkansas. G. G. Becker, San Antonio, Texas.

9. General Discussion—Round Table.

Reports of Committees.

Selection of Officers.

Adjournment.

Program

SECTION OF APICULTURE

F. E. MILLEN, *Chairman* G. M. BENTLEY, *Secretary*

Tuesday Afternoon Session, December 27, 3:00, North Gymnasium, Y. M. C. College

Address by the Chairman, F. E. Millen, Guelph, Canada.

READING OF PAPERS AND DISCUSSIONS

1. The Cause of Fermentation or Souring of Honey. (15 min.) (Lantern.) George E. Marvin, Madison, Wisc.

2. Some Points in Handling Honeybee Packages, Both in Shipping and Installing them. (15 min.) Morley Pettit, Guelph, Canada.

3. The Amoeba Disease of the Honeybee in the United States. (10 min.) J. W. Bulger, Bureau of Entomology, Washington, D. C.

4. Area Cleanup of Foulbrood. (15 min.) F. E. Millen, Guelph; Canada.

5. New Diseases of Honeybees. (10 min.) C. E. Burnside, Washington, D. C.

Program

Wednesday Morning Session, December 28, 9:30

SECTION OF APICULTURE—*Continued*

READING OF PAPERS AND DISCUSSIONS

6. Disinfecting Combs. (15 min.) G. L. Jarvis, Guelph, Canada.
7. Colony Population. (10 min.) W. J. Nolan, Washington, D.C.
8. Crop Failure. (10 min.) J. M. Robinson, Auburn, Ala.
9. Marketing Honey. (15 min.) George E. Demuth, Medina, Ohio.
10. The Pathogenic Effect of the Mite, *Acarapis woodi* Hirst, on the Thoracic Tissues of the Honeybee. (5 min.) (Lantern.) E. J. Anderson, State College, Pa.

SYMPOSIUM—PROGRESS REPORTS IN APICULTURAL RESEARCH

Led by J. I. Hambleton, Washington, D. C.

Reports of Committees.

Selection of Officers.

Adjournment.

Program

AMERICAN ASSOCIATION OF ECONOMIC ENTOMOLOGISTS

Wednesday Afternoon Session, December 28, 1:30, North Gymnasium, Y. M. C. College

Report of the Secretary.

Report of the Executive Committee, by President R. W. Harned.

Report of the Representative to the National Research Council, by W. A. Riley, St. Paul, Minn.

Report of the Committee on Policy, by Arthur Gibson, Ottawa, Canada.

Report of the Trustees of the Crop Protection Institute, by W. C. O'Kane, Durham, N. H.

Report of Scientific Trustee, Tropical Plant Research Foundation, by Herbert Osborn, Columbus, Ohio.

Report of the Representatives on the Council of the Union of American Biological Societies, by A. L. Quaintance, Washington, D. C.

Report of the Committee on Nomenclature, by E. O. Essig, Berkeley, Calif.

Report of Committee on Endowment, by A. F. Burgess, Melrose Highlands, Mass.

Report of Editorial Board on Index to Economic Entomology, by E. P. Felt, Albany, N. Y.

Report of Board of Trustees for Permanent Fund, by C. W. Collins, Melrose Highlands, Mass.

Report of the Committee on United States National Museum, by W. E. Hinds, Baton Rouge, La.

Report of Program Committee, by W. E. Britton, New Haven, Conn.

Report of Committee to Formulate Plans for Investigation of the Codling Moth from Biologic and Control Standpoints. by A. L. Quaintance. Washington, D. C.

Report of Advisory Committee, Entomologists and Agronomists on Research and Control of European Corn Borer, by George A. Dean, Manhattan, Kansas.

Report of Committee on Insect Pest Survey, by C. R. Crosby, Ithaca, N. Y.

Report of Representative to International Zoological Congress at Budapest, Hungary, by L. O. Howard, Washington, D. C.

Report of the Committee on Amendment to the Constitution by P. A. Glenn, Urbana, Ill.

Report of Committee for Holding 4th International Entomological Congress in America, by L. O. Howard, Washington, D. C.

Remarks—4th International Entomological Congress, by G. W. Herrick, Ithaca, N. Y.

Appointment of Committees.

Miscellaneous Business.

New Business.

Annual Address of the President, R. W. Harned, A. & M. College, Miss.

1. Entomology in the Southern States

Discussion of the Presidential Address.

READING OF PAPERS

Insects Affecting Cereal, Forage and Field Crops

(European Corn Borer)

2. The Status of the European Corn Borer in Canada (1927). (5 min.) L. S. McLaine and H. G. Crawford, Entomological Branch, Ottawa, Canada.

A brief report on the extent of spread and the increase in intensity of infestation in certain sections.

3. Corn Borer Research and the Ten Million Dollar Clean-up Campaign. (5 min.) (Lantern.) D. J. Caffrey, Corn Borer Laboratory, Arlington, Mass.

4. Corn Borer Control and the Ten Million Dollar Clean-up Campaign. (5 min.) L. H. Worthley, 615 Front Street, Toledo, Ohio.

5. Results of the Ten Million Dollar Corn Borer Clean-up Campaign. (5 min.) W. H. Larrimer, Bureau of Entomology, Washington, D. C.

6. The Correlation of European Corn Borer Accumulation with Soil Fertility. (5 min.) (Lantern.) L. L. Huber and C. R. Neiswander, Ohio Experiment Station, Wooster, Ohio.

In a former paper (1926) it was pointed out that certain vegetative types may be used as indices of corn borer accumulations. This paper will show that soil fertility may likewise be correlated with the rapid accumulation of the insect.

7. Fundamental Phases of European Corn Borer Research. (5 min.) L. L. Huber, Wooster, Ohio and D. J. Caffrey, Arlington, Mass.

A general discussion of results and plans for development in corn borer investigations pertaining to parasites, insecticides, mechanical measures and cultural practices.

Program

Thursday Morning Session, December 29, 9:30

SYMPOSIUM ON INSECTICIDES

8. Recent Developments in Proprietary Insecticides. (10 min.) W. S. Abbott, Bureau of Entomology, Vienna, Va.

9. Soil Insecticides. (10 min.) W. E. Fleming, Japanese Beetle Laboratory, Moorestown, N. J.

10. The Relative Toxicities of Arsenicals and Fluorine Compounds to Various Organisms. (10 min.) (Lantern.) S. Marcovitch, Agricultural Experiment Station, Knoxville, Tenn.

11. Comments on the Determination of the Relative Toxicity of Insecticides. (10 min.) C. H. Richardson, Bureau of Entomology, Washington, D. C.

READING OF PAPERS

Insecticides and Appliances

12. Testing New Insecticides. (5 min.) L. Haseman, Columbia, Mo.

A brief discussion of the ever increasing flood of new insecticides and the importance of entomologists co-operating with the Federal Insecticide and Fungicide Board in eliminating the worthless brands from the market.

13. Fish Oil as an Adhesive in Control of Codling and Grape berry Moths. (5 min.) H. L. Dozier, Agricultural Experiment Station, Newark, Del.

A brief report of preliminary work, showing its possibilities, in orchard and vineyard.

14. Analyses of Sprayed Apples for Lead and Arsenic. (5 min.) (Lantern.) Albert Hartzell and Frank Wilcoxon, Boyce Thompson Institute for Plant Research, Yonkers, N. Y.

In continuation of work reported in 1926, analytical data are presented for lead and arsenic on apples sprayed according to a standard schedule during the season of 1927.

15. The Results of Three Years Work with the Dust Sprays in Missouri. (5 min.) K. C. Sullivan, Columbia, Mo.

The general results indicate that the dusts should be used only as a supplement to the liquid sprays.

16. Physiological Studies on the Effect of Fluorides and Fluosilicates on the Respiratory Metabolism of Insects. (5 min.) (Lantern.) David E. Fink, University of Pennsylvania, Philadelphia, Pa.

17. Toxicity of Lead to Insects. (5 min.) F. J. Brinley, University of Pennsylvania, Philadelphia, Pa.

Certain lead salts are definitely toxic to tent caterpillars. The amount of lead in the body of the insect, exclusive of the alimentary canal, remains constant regardless of the quantity of lead consumed.

18. Recent Developments in Pear Psylla Control. (5 min.) H. J. Grady, 209 Clark Street, Augusta, Kansas.

The use of summer oil (Volck) in the summer control of psylla and the results obtained the past two seasons.

19. A Bibliography of Ethylene Dichloride (Read by title.) W. A. Gersdorff and R. C. Roark, Bureau of Chemistry and Soils, Washington, D. C.

20. The Composition of Fluorides and Fluosilicates Sold as Insecticides. (Read by title.) R. H. Carter and R. C. Roark, Washington, D. C.

21. Fumigation Tests with Certain Chlorinated Hydrocarbons. (5 min.) R. C. Roark, Bureau of Chemistry and R. T. Cotton, Bureau of Entomology, Washington, D. C.

Tests with aliphatic chlorides as fumigants are reported upon. Many of these chlorides are commercially available, cheap, not readily inflammable, non-injurious to man, and are toxic to insects.

INSECTS AFFECTING THE HOUSEHOLD AND STORED PRODUCTS

22. House and Flour Mill Fumigation with Calcyanide. (5 min.) Roger C. Smith, Agricultural College, Manhattan, Kansas.

A summary of a series of tests with this material with a discussion of the factors involved in this type of fumigation.

23. Preventing Insect Damage to Stored Grains. (5 min.) (Lantern.) W. P. Flint, State Entomologist Building, Urbana, Ill.

A number of chemicals were mixed with the grain and it was then exposed to infestation. Several of these materials, notably mixtures of hydrated lime and creosote, copper carbonate, and calcium fluosilicate gave very good protection.

24. Control of Insects in Stored Seeds with Organic Mercury Compounds. (5 min.) J. L. Horsfall, 1086 N. Broadway, Yonkers, N. Y.

Preliminary report showing that beans, corn and wheat treated with nitrophenol mercury and chlorophenol mercury in dust form furnishes a control of certain insects while the seeds are in storage.

25. The Toxicity of Fumigants as Affected by the Presence of Grain. (5 min.) A. L. Strand, University of Minnesota, St. Paul, Minn.

26. Cyanogas Calcium Cyanide for the Fumigation of Flour Mills. (5 min.) S. W. Bromley, 535 Fifth Avenue, New York, N. Y.

The application of Cyanogas Calcium Cyanide has proven a simple, effective and comparatively safe method of utilizing HCN in the fumigation of flour mills. The development of the method is described in the present paper.

27. Experiments with Vacuum-Disulphid Fumigation of Dried Figs Under Commercial Conditions. (5 min.) J. C. Hamlin and W. D. Reed, Box 2696, Tampa, Fla.

Presents experimental data on this method of vacuum fumigation in relation to effectiveness against revival and survival of treated insects at various seasons of the year.

28. Macroscopical Examination of Fumigated Plodia Larvae in Relation to Their Revival Potentialities. (5 min.) J. C. Hamlin and W. D. Reed, Box 2696, Tampa, Fla.

Observations on the external characteristics of larvae reviving after fumigation with carbon disulphid.

29. Moth-proofing Solutions. (5 min.) (Lantern.) E. A. Back and R. T. Cotton, Bureau of Entomology, Washington, D. C.

Statement regarding the composition, use and effectiveness of these solutions.

Program

Thursday Afternoon Session, December 29, 1:30

JOINT SESSION, MAIN ASSOCIATION WITH COTTON STATES BRANCH

Reading of Papers

30. Summary of Boll Weevil Damage to Cotton in the South in 1927. (5 min.) R. W. Leiby, Raleigh, N. C.

Compilation of damage by various entomologists in the cotton states.

31. Four Years of Boll Weevil Control under Uniform Soil Conditions in Alabama. (5 min.) (Lantern.) J. M. Robinson, Auburn, Ala.

32. Oviposition Rate of the Boll Weevil in Relationship to Food. (5 min.) (Lantern.) Dwight Isely, University of Arkansas, Fayetteville, Ark.

Relation of squares and bolls as food of adult weevils to the rate of oviposition.

33. The Preparation of a Special Light Sodium Fluosilicate and its Use as a Boll Weevil Poison. (Lantern.) H. W. Walker, Chemical Warfare Service, Edgewood, Md.

34. The Preparation of Special Calcium Arsenates Containing Less Than 40% Arsenic as As_2O_5 and Their Use as Boll Weevil Poisons. (Lantern.) H. W. Walker, Edgewood, Md.

35. Calcium Arsenate as a Cause of Aphis Infestation. (5 min.) J. W. Folsom, Bureau of Entomology, Tallulah, La.

36. Biological Control of the Green Citrus Aphid (*Aphis spiraecola* Patch) in Florida. (5 min.) (Lantern.) R. L. Miller, Ohio State Univ., Columbus, O.

This paper comprises a summary of work done and observations made on the abundance, seasonal appearance and economic importance of all natural enemies of the green citrus aphid.

37. A Preliminary Report on the Toxic Value of Fluosilicates and Arsenicals as tested on the Plum Curculio. (5 min.) (Lantern.) Oliver I. Snapp, Bureau of Entomology, Fort Valley, Ga.

The results of fifty feeding tests in which sodium and calcium fluosilicates and eight arsenicals are used.

INSECTS AFFECTING TRUCK CROPS

38. The Present Status of the Mexican Bean Beetle. (5 min.) (Lantern.) N. F. Howard, Bureau of Entomology, Columbus, Ohio.

A brief statement of the spread and damage by this insect during 1927 and suggestions as to future investigations.

39. The Economic Importance of the Bean Leaf Hopper in North Carolina. (5 min.) (Lantern.) Z. P. Metcalf, State College Station, Raleigh, N. C.

A brief discussion of the damage caused by this insect to beans, soy beans, peanuts and cotton in North Carolina.

40. Some Further Observations upon the Biology and Control of *Empoasca fabae*. (5 min.) (Lantern.) D. M. DeLong, Ohio State University, Columbus, O.

Seasonal occurrence, preferred host plants, life history observations, seasonal generation and comparative control results.

41. Investigations of the Potato Tuberworm, *Phthorimaeae operculella* Zell., in Virginia during 1926 and 1927. (5 min.) F. W. Poos and H. S. Peters, Virginia Truck Experiment Station, Norfolk, Va.

History and importance in Virginia. Further studies on biology and control.

42. Some Chemotropic Responses of the Tobacco Hornworm Moth. (5 min.) (Lantern.) A. C. Morgan and S. C. Lyon, Box 346, Clarksville, Tenn.

Amyl Salicylate incites a decided feeding response in Tobacco Hornworm moths. Amyl Benzoate is also very attractive. Large numbers of Tobacco Moths and other Sphingidae were caught in traps baited with Amyl Salicylate.

43. Tarnished Plant Bug Injury to Strawberries. (5 min.) (Lantern.) L. Haseman, University of Missouri, Columbia, Mo.

Brief discussion of a very severe attack of tarnished plant bug resulting in practically a hundred per cent loss over a considerable acreage of strawberries in Southwest Missouri.

INSECTS AFFECTING MAN AND ANIMALS

44. The Toxicity to Flies of Certain Materials Used as Fly Sprays. (5 min.) H. M. Brundrett, F. C. Bishopp and E. W. Laake, Bureau Entomology, Washington, D. C.

A preliminary statement on the results of experiments to determine an effective toxic spray for use against flies, including a brief discussion of the equipment, and methods employed in the studies.

Program

Friday Morning Session, December 30, 9:30

READING OF PAPERS

Insects Affecting Cereal, Forage and Field Crops

45. The Hibernation of Chinch Bugs (*Blissus leucopterus* Say) in Sudan Grass. (Read by title.) H. R. Bryson, Agricultural College, Manhattan, Kansas.

A study relating to the efficiency of Sudan grass stubble and uncut bunches as overwintering quarters for the chinch bug.

46. Ecological Studies of Scarabaeid Larvae. (5 min.) (Lantern.) J. W. McColloch and W. P. Hayes, Manhattan, Kansas and Urbana, Ill.

A study of the mortality, food habits, habitat preference and abundance of larvae made during eight years observation.

47. A Power-Driven Grasshopper Catcher. (5 min.) (Lantern.) W. C. O'Kane, State Entomologist, Durham, N. H.

48. The Influence of Temperature on the Feeding of Grasshoppers. (5 min.) G. S. Langford, Fort Collins, Colo.

A new method for studying the food habits of grasshoppers, the results obtained and their relation to temperature.

49. Alfalfa Yellow Top and Leafhoppers. (5 min.) (Lantern.) A. A. Granovsky, University of Wisconsin, Madison, Wisc.

50. Hibernation of the Grape Colaspis, *Colaspis brunnea* Fab. (4 min.) J. H. Bigger, 1114 S. Main Street, Jacksonville, Ill.

Information on hibernation habits of this insect. Notes made in connection with life history studies of this insect on red clover and corn.

51. Insecticidal Control for the Sugarcane Borer. (5 min.) W. E. Hinds and Herbert Spencer, Louisiana Experiment Station, Baton Rouge, La.

Presenting the most significant results from three seasons of field work in the control of *Diatraea saccharalis* by dust applications of Sodium silicofluoride.

52. Utilization of *Trichogramma minutum* in Sugarcane Borer Control. (5 min.) (Lantern.) Herbert Spencer and W. E. Hinds, Baton Rouge, La.

Presenting results of field examinations in borer control occurring naturally during two seasons and describing methods and plans for increasing the effectiveness of this most important native parasite of the cane borer.

53. Some Temperature Relations of Melanotus (Coleoptera). (3 min.) B. B. Fulton, Iowa State College, Ames, Iowa.

Experiments on temperature tolerance of wireworm larvae and adults in relation to distribution and habits.

54. *Barathra configurata* Wlk., an Armyworm of Important Potentialities in the Prairies. (5 min.) K. M. King, Entomological Laboratory, Saskatoon, Can.

This paper deals chiefly with the life history, economic importance and means of distinguishing the immature stages from several other species of similar habits or appearance.

55. Wireworms and False Wireworms of Economic Importance in Saskatchewan. (5 min.) K. M. King, Entomological Laboratory, Saskatoon, Can.

Discusses the present and potential economic status of wireworms in Saskatchewan, with estimates of crop losses caused by them in 1926, and detailed examples of injured fields.

Insects Affecting Forest and Shade Trees and Ornamental Plants

56. Hot Water Immersion for the Control of the Box Leaf Miner, *Monarthropalpus buxi*. (5 min.) (Lantern.) F. F. Smith, H. J. Fisher and T. L. Guyton, Department of Agriculture, Harrisburg, Pa.

The development of a new treatment for this serious pest of box wood in which a water bath is used at the temperature of 120 degrees F., with seven minutes duration, or 122 with five minutes duration gave satisfactory control.

57. Injection Experiments for Controlling Insects. (5 min.) W. O. Hollister, Davey Tree Expert Co., Kent, Ohio.

Discussion of methods of injection, materials used, effect on trees and insects.

58. Present Status of the Gipsy Moth Problem. (5 min.) (Lantern.) A. F. Burgess, Melrose Highlands, Mass.

59. Small Mammals and the Larch Sawfly. (5 min.) S. A. Graham, Univ. of Michigan, Ann Arbor, Mich.

This paper summarizes the results to date of a series of quantitative experiments of the effect of various factors, particularly the effect of mice and shrews upon the abundance of the larch sawfly.

Insects Affecting Deciduous Fruits

(Japanese Beetle)

60. Some Phases of the Japanese Beetle Insecticide Investigations. (5 min.) E. R. Van Leeuwen, Box H, Moorestown, N. J.

This paper is limited to a discussion of some of the problems and difficulties experienced, as well as the progress made in the insecticide work against the adult Japanese beetle.

61. A Trap for the Japanese Beetle (*Popillia japonica* Newm.). (5 min.) (Lantern.) E. Avery Richmond and F. W. Metzger, Box H. Moorestown, N. J.

Four years' experiences relative to the evolution of a trap for the Japanese beetle.

62. Hot Water as an Insecticide for the Japanese Beetle in the Roots of Nursery Stock. (5 min.) W. E. Fleming, Riverton, N. J.

63. Progress with the Imported Parasites of the Japanese Beetle during 1927. (5 min.) (Lantern.) H. W. Allen and H. A. Jaynes, Box H, Moorestown, N. J.

A summary of the work with introduced parasites and the results obtained at the Japanese Beetle Laboratory, Riverton, N. J., since January 1, 1927.

Program

Friday Afternoon Session, December 30, 1:30

READING OF PAPERS

INSECTS AFFECTING DECIDUOUS FRUITS—*Continued*

64. The European Red Mite. (5 min.) (Lantern.) J. S. Houser, Wooster, O.

Record of control experiments and interpretation of results.

65. Observations on European Red Mite. (5 min.) J. G. Sanders, Sun Oil Company, Philadelphia, Pa.

66. The Codling Moth as an Established Pest of Stone Fruits. (5 min.) Ralph H. Smith, Citrus Experiment Station, Riverside, Calif.

Recent investigations indicate that the codling moth has become established on plums and peaches in parts of California.

67. Codling Moth Hibernation Studies. (5 min.) (Lantern.) S. C. Chandler, Route 5, Carbondale, Ill.

These studies indicate relative numbers of hibernating larvae on different parts of the trunks of apple trees and in various types of cover between the trees. Results are given of applications of contact sprays against hibernating larvae.

68. An Investigation of Spray Coverages and Arsenical Residue in Relation to Codling Moth Control. (5 min.) R. H. Smith, Riverside, Calif.

69. Codling Moth Control in Georgia Apple Orchards. (5 min.) C. H. Alden and M. S. Yeomans, Cornelia, Ga.

Life history, dusting and spraying, and banding experiments conducted in the apple orchards of North Georgia during the 1927 season for the control of the codling moth.

70. Second Report on Chemically Treated Bands for Destruction of Codling Moth Larvae. (5 min.) E. H. Siegler, Luther Brown, A. J. Ackerman and E. R. Van Leeuwen, Bureau of Entomology, Silver Spring, Md.

Results of tests with chemically treated bands indicate the possibility that such bands may be employed in place of the old type band. Hand labor is required to destroy the codling moth larvae that spin beneath the old type band. The chemically treated bands are self-acting.

71. Tropic Responses of Codling-moth Larvae. (5 min.) N. E. McIndoo, Bureau of Entomology, Washington, D. C.

Throws light on biology of codling moth and explains why larvae go under bands.

72. Is the Codling Moth Attracted by Light? (5 min.) M. A. Yothers, Box 243, Yakima, Wash.

It has long been supposed that the codling moth was not attracted by lights. Recent tests show this is not true. Brief resume of experiments in 1926 and 1927 are presented.

73. Relative Resistance to Arsenical Poisoning of two Codling Moth Strains. (5 min.) (Lantern.) W. S. Hough, Winchester, Va.

A summary of one year's investigation of the comparative resistance to lead arsenate poisoning of Colorado and Virginia codling moth larvae.

74. An Operation in Practical Control of Codling Moth in a Heavily Infested District—Second Report. (5 min.) T. J. Headlee, New Brunswick, N. J.

This paper is a continuation of the work carried on in 1926 and reported in the last annual meeting. The work of 1927 shows a further advance in clean fruit.

75. Report on Orchard Tests Conducted during 1927 for the Control of Codling Moth in the Yakima Valley, Washington. (5 min.) W. S. Regan and A. B. Davenport, Box 853, Yakima, Wash.

Tests continued on several varieties of apples and pears with combination arsenate of lead and oil and oil alone. Five different oils tested.

76. Continued Studies with Baits for the Oriental Fruit Moth. (5 min.) S. W. Frost, Arendtsville, Pa.

This paper includes (1) comparative tests with various baits; (2) factors affecting the catches of moths, and (3) value of bait pails as a means of control.

77. Preliminary Tests with Possible Repellents for the Oriental Peach Moth. (Read by title.) Joseph W. Lipp, 228 E. Upsal St., Mt. Airy, Phila., Pa.

Methods and materials used are discussed in this paper.

78. The Determination of the Spring Brood of Oriental Peach Moths and Codling Moths Using Various Methods. (5 min.) (Lantern.) Alvah Peterson and G. J. Haeussler, Japanese Beetle Laboratory, Moorestown, N. J.

Overwintering cocoons of both species were placed in various types of cages and containers and located in orchards and in a packing shed. Striking difference in the time of emergence of the adults took place in varying locations and containers.

79. Factors which Enter into the Control of the Pecan Nut Casebearer. (5 min.) G. F. Moznette, P. O. Box 482, Albany, Ga.

A study of the feeding habits of *Acrobasis caryae* Grote and their bearing on control with lead arsenate.

80. A New Insect Pest of Pecans—in Alabama. Tetralopha sp. (5 min.) J. M. Robinson, Auburn, Ala.

MISCELLANEOUS

81. Water Conservation in Insects. (5 min.) William Robinson, University of Minnesota, St. Paul, Minn.

Insects which live on food low in water have the capacity, like the cactus, of holding much of their water in the bound or colloidal condition. This capacity varies directly as the total water content of the insect.

82. Precipitation as a Measure of the Moisture Factor in the Ecology on Insects in Irrigated Regions. (5 min.) (Lantern.) H. L. Sweetman, Laramie, Wyo.

Precipitation studies in the Western States do not give a true impression of the moisture environment to which insects are exposed in irrigated fields.

83. The Bionomics of *Polynema striaticorne* Girault (Mymaridae, Hymenoptera), a Parasite in the Egg of the Buffalo Tree Hopper, *Ceresa bubalus* Fab., (Membracidae, Homoptera). (5 min.) (Lantern.) W. V. Balduf, University Illinois, Urbana, Ill.

1. Observations on the host. 2. The habits of the parasite, and its development. 3. The economic importance of the parasite.

84. Quantitative Results in the Prediction of Insect Abundance on the Basis of Biotic Potential and Environmental Resistance. (5 min.) R. N. Chapman, University Farm, St. Paul, Minn.

85. European Entomology and Entomologists. (5 min.) R. N. Chapman, University Farm, St. Paul, Minn.

Program

Saturday Morning Session, December 31, 9:30

READING OF PAPERS

Insects Affecting Bulbs and Greenhouse Crops and Tropical and Subtropical Plants

86. Mushroom Insects: Observations on their Life-histories, Habits and Control. (5 min.) C. A. Thomas, Pa. State College Laboratory, Bustleton, Pa.

Observations on the biology of Sciarid and Phorid Flies, Springtails and Tyroglyphid Mites affecting cultivated mushrooms, together with the results of some control experiments.

87. Results of Forcing Hot Water Treated Narcissus Bulbs. (5 min.) (Lantern.) C. A. Weigel, Bureau of Entomology, Washington, D. C.

Discusses flowering results obtained with bulbs which have been given the hot water treatment which is used for the control of the narcissus fly, *Merodon equestris*, and the lesser bulb fly, *Eumerus* spp.

88. Developmental History of the Narcissus Bulb Fly at Washington, D. C. (5 min.) (Miss) B. M. Broadbent, 2224 Gentilly Road, New Orleans, La.

Brief review of development of *Merodon equestris*, including notes on duration of larval period, and total time from egg deposition to emergence of fly.

89. Observations on the Habits and Control of the Garden Centipede, *Scutigerella immaculata* Newport, a Pest in Greenhouses. (5 min.) (Lantern.) G. A. Filinger, Ohio Experiment Station, Wooster, Ohio.

A discussion of the habits of the garden centipede as observed in greenhouses and some of the results obtained with several control measures.

90. Estimating the Toxicity of Oil Emulsions to Camphor Scale. (5 min.) (Lantern.) C. I. Bliss and A. W. Cressman, 2224 Gentilly Road, New Orleans, La.

Environmental factors influencing normal mortality in overwintering camphor scale. Their effect on spray counts. Relation of oil concentration and density of scale population to survival.

FINAL BUSINESS

Report of Committee on Resolutions.
Report of Committee on Membership.
Reports of other committees.
Nomination of JOURNAL officers by advisory committee.
Report of Committee on Nominations.
Election of Officers.
Miscellaneous business.
Fixing the time and place of next meeting.
Final adjournment.

R. W. HARNED, *President*,
A. & M. College, Miss.

C. W. COLLINS, *Secretary*,
Melrose Highlands, Mass.

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MALLOPHAGA of birds from all parts of North America wanted, especially the genus Degeeriella. H. S. Peters, Virginia Truck Experiment Station, Norfolk, Virginia.

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